

# The Interaction Design of Household Intelligent Breathing Training System

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**Abstract.** This paper achieved the acquisition of the breathing signal and identification of different respiratory modes by several attempts. On this basis, we designed an intelligent breathing-exercise system to meet the household needs. The intelligent system consists of three parts: the first part is the user interface of the breathing-exercise system, the second part is the background database and the last part is the internet community platform. The user interface of the breathing-exercise system is used for displaying user's breathing curve and other visual feedback. All the breathing training data will be recorded in the second part: database. Those breathing exercisers can share their results on the internet community platform. The intelligent breathing-exercise system will provide a memorable user experience for users by blending these three parts.

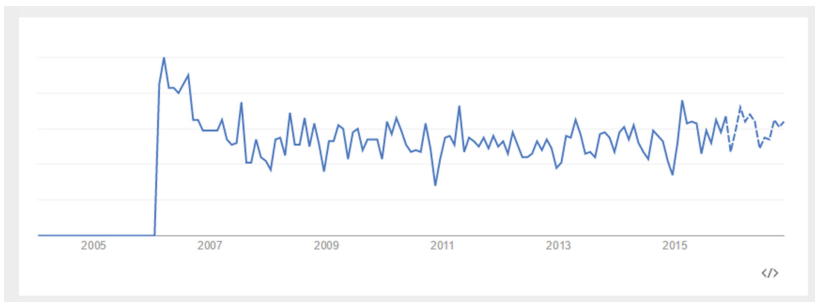
**Keywords:** Breathing training system · Interaction design

## 1 Introduction

Nowadays, as the air pollution is getting worse and the incidence of respiratory disease is becoming soaring, more and more people are concerned about the topic of breathing exercise. From the current point of view, research on the breathing exercise and product development are mostly concentrated in the medical field. These studies focus on two major problems: the first one is the treatment of respiratory diseases and the second one is the rehabilitation of respiratory diseases. American Academy of Family Physicians (AAFP) found that those with COPD (Chronic obstructive pulmonary disease) who use breathing exercises experience greater improvements in exercise capacity than those who do not. So, the fact is breathing exercise is really an effective treatment way for those respiratory diseases like Chronic obstructive pulmonary disease, Chronic pneumonia and other respiratory diseases. According to the survey, we find that the typical products include the breathing training device and the respiratory therapy device. These medical devices are so highly targeted and professional that they are difficult to meet the needs of breathing training in home. In terms of the range of application, these medical breathing trainers are a bit more restrictive. With wearable healthy devices becoming more and more popular, people started to pay more attention to their own health data. It is easy to calculate that people want to get the respiratory data by household intelligent devices. This shows a household intelligent breathing exercise

device will be more practical than a medical breathing training device. So, it is not difficult to find that household intelligent breathing trainer has broad research space and market prospects.

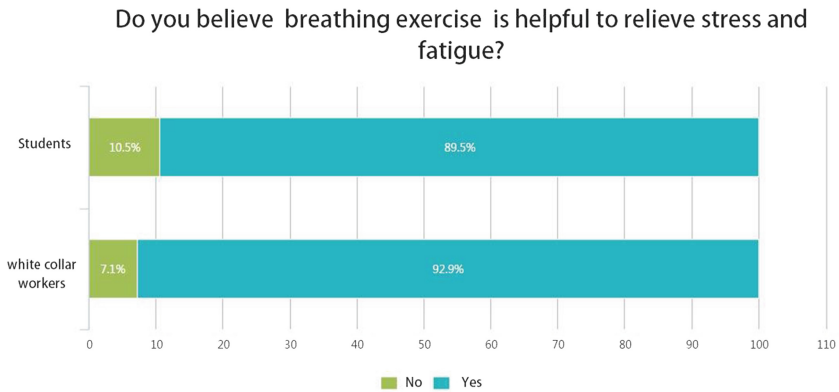
As we all know, the daily breathing exercise is an important means of strengthening respiratory muscles, which can improve respiratory function and relieve mental stress and tension. Abnormalities in respiration have been postulated as an important factor in the development or maintenance of anxiety disorders [1]. It can be known that breathing training is an effective way to treating the panic disorder. When we talking about daily breathing training, it is inevitable to introduce an important breathing training way: Lamaze breathing. Lamaze breathing historically is considered the hallmark of Lamaze preparation for childbirth [2]. The breathing method is generally considered as a controlled breathing way to enhance relaxation and decrease perception of pain. Conscious breathing and relaxation, especially in combination with a wide variety of comfort strategies, can help women avoid unnecessary medical intervention and have a safe, healthy birth. In restricted birthing environments, breathing may be the only comfort strategy available to women. The deep-breathing also called abdominal respiration is well known another important breathing method to reduce feelings of stress. We cannot ignore that most of the office workers have to face the computer all day to accomplish their works in stressful working conditions. According to the survey, people who face the computer for a long time will be in a short-winded breathing mode, which will lead to insufficient ventilation even in the normal respiratory rate. Apart from the insufficient ventilation, the carbon dioxide will accumulate gradually in the short-winded breathing status and then lead to Listlessness. All the shortcomings above described will result in adversely affect for people. Conversely, if they take a deep breath training, they will be benefited greatly including the improvement of the lung capacity, the improvement of alveolar utilization rate and so on. In view of this, design and development of a suitable daily breathing exercise interactive system has a high practical value and huge market potential. Figure 1 shows the trend of the keyword “breathing training” in Google search. As can be seen from the figure, since the 2006 “breathing training” peaked a search until the year 2015. So far, the heat of search is still maintained at between 60 and 80.



**Fig. 1.** The trend of “breathing training” in Google search

## 1.1 Research of the Breathing Training

We designed a questionnaire of the breathing exercises to understand some of the current problems that exist in breathing exercise. We sent 33 questionnaires and all the questionnaires are recovered successfully, of which include 14 white-collar workers and 19 students. According to survey results, 92.9 percent of white-collar workers said deep breathing exercises help relieve stress and fatigue. 89.5 % of the student population believe that the deep breathing exercises contribute to relieve stress as we can see in Fig. 2.



**Fig. 2.** The survey about the relieving stress by breathing training

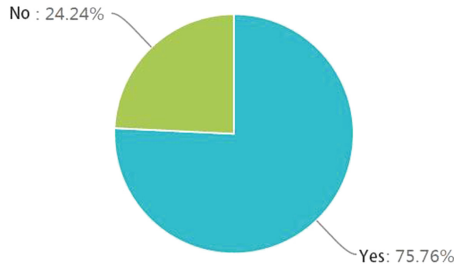
At the same time, we made a simple research for other problems existed in breathing exercise, such as the persistence of the breathing training. Results of the research show that 75.76 % of respondents find it difficult to adhere to the breathing exercise shown in Fig. 3.

## 1.2 Research Status

As we all known, breathing training can strengthen breathing muscles, relieve stress and promote the rehabilitation of lung function, and thus play to enhance physical fitness, disease prevention and promote rehabilitation. A variety of detection devices and instruments abound in the study of aspects of breathing exercise. Which are more representative of the product at home and abroad, as described below.

Gila Benchetrit from French designed a breathing exercise apparatus to collect respiration signal by a sleeveless jacket [3]. The principle of the device is equipped with a sleeveless jacket can be folded in a special material that can be received by a lateral extension of the diaphragm, abdominal volume change. The device can also filter out the biggest natural breathing graphics, and based on the graphical boot subject's breathing lungs rehabilitation training.

Do you find it difficult to adhere to the breathing exercise?



**Fig. 3.** The survey about the persistence of the breathing training

Bardon Technology Institute in Beijing developed a respiratory therapy device based on biofeedback can be used for the adjuvant treatment of breathing difficulties. The therapy device can measure respiration rate, and gives real-time feedback.

According to the review above, we can see that there are still some deficiencies in current research breathing exercise, which mostly focus on the respiratory signal acquisition and feedback on their own. The form of respiratory signal feedback in the majority of studies seems monotonous and boring. Besides, most of the studies pay less attention to daily breathing exercise. So, it is not difficult to find that a household intelligent breathing training system maybe a more reasonable solution.

## 2 The Acquisition and Processing of Respiration Signal

Nowadays, respiration signal detected in clinical care has been one of the more important indicators. With the development of society and technology, real-time, dynamic and continuous monitoring of the respiratory signal will become the future trend of family health. Through research and pilot testing, we decide to use a kind of acoustic signal to characterize breathing signals. This method seems safe, simple and non-invasive compared to other methods, and provides a more flexible way to wear. Relying on the microphone with advanced noise reduction and filtering processing, we can get more accurate and clear identification of the respiratory signal.

After determining to characterize the respiratory signal using acoustic signals, we need to collect the original acoustic signal and process the signal by using pre-emphasis method firstly. Given the MATLAB software owns powerful features in signal processing and acquisition, in this study, we use MATLAB to collect and process breathe signal. In MATLAB software, there are two ways to collect acoustic signals, one of which is the acquisition of analog signals, and the other is using of “audiorecorder” function to achieve signal acquisition. This paper uses the second way, which is using “audiorecorder” function to achieve the acquisition of acoustic signal. We can see the original respiratory signal waveform from Fig. 3 clearly.

The high frequency part of the proportion is small in the collected acoustic signal. The aim of the pre-emphasis is to boost the high frequency part of the process, so that the spectrum of the signal become flat. By means of the filter function in MATLAB, we can directly implement the pre-emphasis of the acoustic signal. As we can see, Fig. 4 shows the Pre-emphasis waveform of the breathing signal.

To be able to see the trends and changes of the respiratory signal waveform, we need to make further processing for the waveform diagram. Short-term energy is an important method for time-domain signal analysis, which can clearly show trends and changes in the amplitude of the waveform. As we can see in Fig. 5, short-term energy diagram shows the time-varying characteristics of the respiratory signal.

On the basis of short-term energy chart, we need to judge the critical point between the exhale signal and the inhale signal. After several tests and debugging, the paper found the demarcation point between exhalation and inhalation signals, and according to this cut-off point made a further clipping processing. Finally, we get a clear exhalation and inhalation waveform shown in Fig. 6.

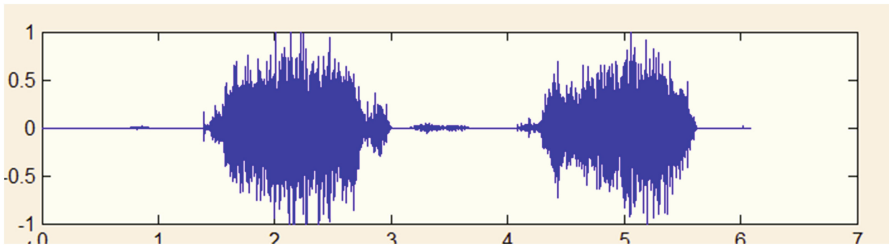


Fig. 4. Original waveform of the breathing signal

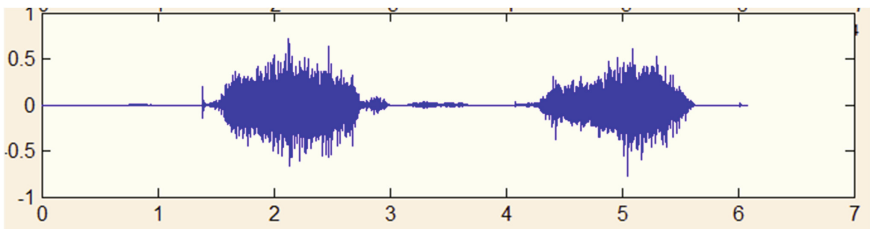


Fig. 5. Pre-emphasis of the breathing signal

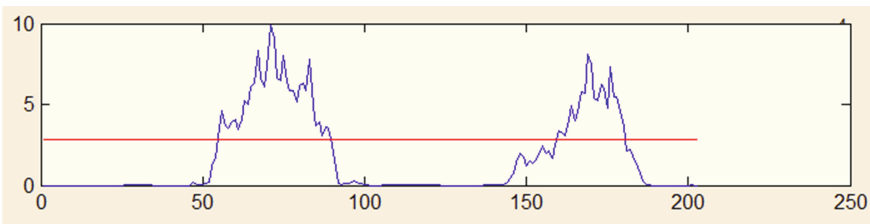


Fig. 6. Short-term energy diagram

### 3 The Interaction Design of the Breathing Training System

#### 3.1 The Development Principle of the Household Intelligent Breathing Training System

In the above, we have successfully acquired and processed breathing signal by MATLAB software. At the same time, we also verified the feasibility of using acoustic signal to characterize the respiratory signal by MATLAB software. In the following part, we will discuss how to get specific respiratory signal in FLASH actionscript 3.0 Language. Actionscript 3.0 achieved the acquisition of audio signal through a special class called “Microphone”. We can get the class of “Microphone” and set up related properties through the following code:

```
Var mic: Microphone = Microphone.getMicrophone ();
mic.gain = 60;
mic.rate = 11;
mic.setUseEchoSuppression (true);
mic.setLoopBack (true);
mic.setSilenceLevel (5, 1000);
```

“SetSilenceLevel” deserves our attention in these properties, which will determine the value of the smallest sound that can be identified. If the “SetSilenceLevel” parameter is set to zero, the application will continue to collect information from the audio microphone. Conversely, if the silenceLevel parameter is set to 100, the program will prevent the microphone’s activities. According to the previous method for distinguishing between exhalation and inhalation, we only need to set up an appropriate silenceLevel parameter that can achieve the recognition of exhalation and inhalation. Another important property should be valued is “ActivityLevel”, which can characterize the strength of the respiratory signal. We can easily see that the scope of this property is from 0-100 through consulting the manual. In the following interactive system, we will use this property to achieve some interesting interaction effects.

#### 3.2 About Gamification

In order to increase the fun of the interaction system, we introduced the concept of Gamification. Gamification has raised a lot of interest both in industry and also increasingly in academia during the past few years [4]. The word “Gamification” first appeared in the 2010 DICE conference, then with the rapid development of the Internet is gradually well known. A large number of internet companies applying the concept of gamification into practice, made this word become a real solution to the problem from a new vocabulary. The core concept of gamification is applying mechanisms and methods in game to non-gaming areas, thereby enhancing the participants’ enthusiasm and participation. Nowadays, gamification has been widely applied to various fields including education, health care, Internet, design, tourism, business management and

so on. About the definition of “Gamification”, until now, little academic attention has been paid. Sebastian from Hamburg University proposed the following definition: “Gamification” is the use of game design elements in non-game contexts, and then unpacked this definition in his paper [5].

So far, we have a clearer understanding of the concept of the gamification. In the following part, we will introduce some of the commonly used methods in game design, including the rating system, points system, ranking system, and medal system. In addition to the methods of gamification, we should also understand the game mechanics, also known as game elements. The game elements can be classified as self-elements and social-elements. Self-elements consist of points, achievement badges, levels, or simply time restrictions. Social-elements on the other hand are interactive competition or cooperation, like for example leaderboards [6]. In the following interactive system, we will apply these methods and elements to polish our system.

### 3.3 System Design

As we talked in the abstract, this system consists of three parts: the first part is the user interface of the breathing-exercise system, the second part is the background database and the last part is the internet community platform. The following sections unpack the system in detail.

**User Interface.** In this part, what we should consider is how to design appropriate interface and mechanisms to improve the fun and challenge of the system in order to achieve a good training effect. When we design the user interface, we hope to achieve the following three objectives:

1. Interface consistent with user’s mental model
2. Breathing training system has instant visual feedback
3. There is a clear distinction between expiratory and inspiratory phase

After several attempts and thinking, we finalized the interactive program shown in Fig. 7. Users can control the target object by the intensity and duration of inhalation and exhalation, enabling interactive process with the respiratory training system.

The system mainly focuses on two parameters which include the breathing depth and the breathing duration. The spacing between the obstacles is used to control a single duration and the height of obstacle will be used to control breathing depth, as we can see in Fig. 8.

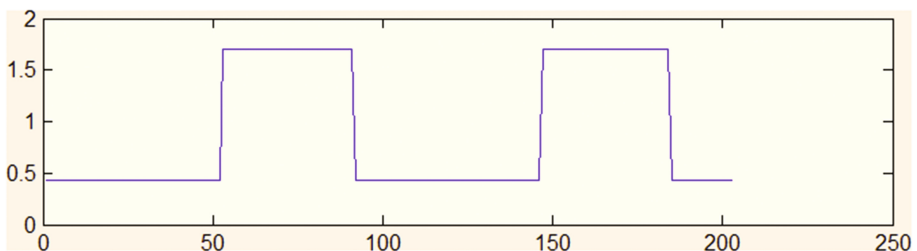


Fig. 7. The waveform after the clipping

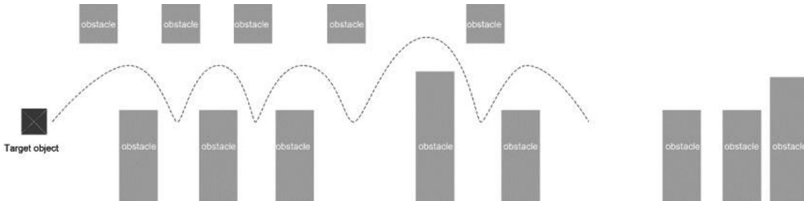


Fig. 8. The layout of the system interface

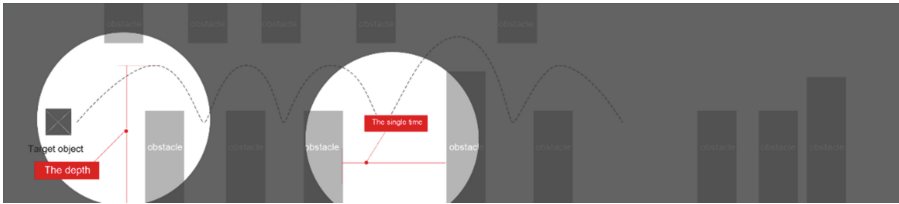


Fig. 9. The breathing depth and breathing duration

On the basis of the interaction design, we established the visual style and interface elements of the respiratory training system. In the terms of overall style, we adopted a flat style, which can reduce people’s cognitive load and highlight the core elements. In terms of color, we adopted a light blue background, giving a fresh and invigorating feeling. We made the green balloons become the focus of the whole picture, in order to make the trainers see the feedback of their training results accurately. The specific visual interface is shown in Fig. 9.



Fig. 10. The visual interface of the breathing training

Users can control the balloon’s rise and fall through their own exhalation and inhalation. At the same time, they need to avoid obstacles at different heights and different pitches. We can adjust the height and spacing of obstacles to achieve different breathing patterns, and thus meet the different needs of different respiratory trainer. We can clearly see the use of the system from the (Figs. 10 and 11).





Fig. 11. Using description of the system description

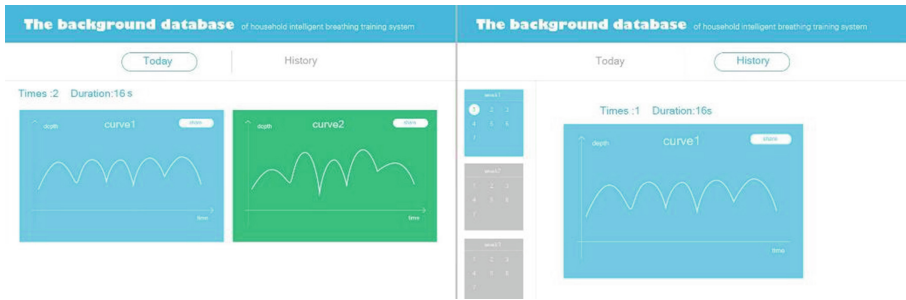


Fig. 12. Background database

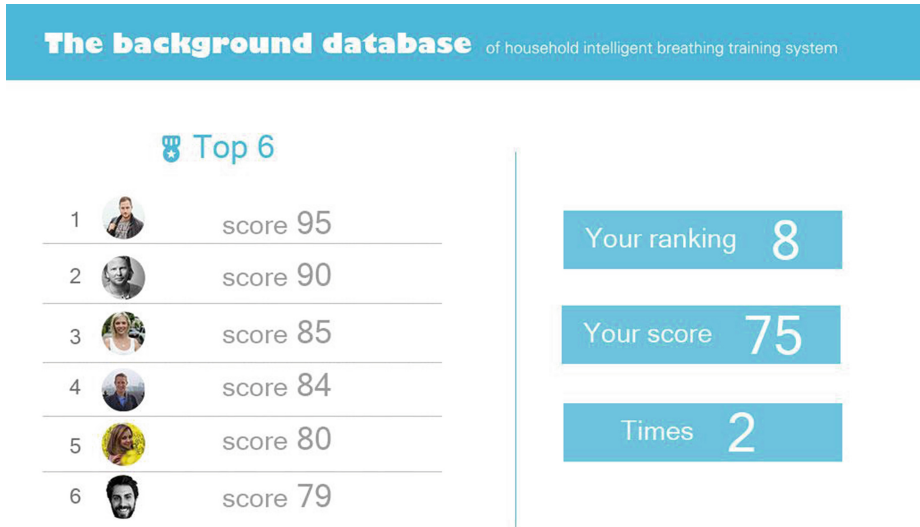


Fig. 13. Rankings of the trainer’s score in community platform

**Background-database.** Background data mainly records the data of the breathing training, which include the times of the exercise, the time of continuous training, and exercise duration, etc. In addition, users can view their own history to understand their dynamic exercise (Fig. 12).

**The internet community platform.** Users can share their own training data and breathing curve in the community and communicate with more people each other. At the same time, users can view the real-time rankings of their score anywhere. Furthermore, if they want to get more professional guidance, they can send their training data to health professionals (Fig. 13).

## 4 Conclusion

First of all, we implemented a new method to acquire the breathe signal by MATLAB software through several attempts and experience. On this basis, we designed a household intelligent breathing training system. At the same time, we introduced the concept of the “Gamification” in the interactive system in order to improve the trainer’s enthusiasm. The household intelligent breathing training system with gamification consists of three parts, which includes user interface, background database and the internet community platform. The user interface is used to display the results of breathing exercise and guides the users through scientific breathing exercise. The second section is used to record the user’s training data. Users can share the results of their training to the community platform, or sent to the health professional to get professional guidance through the third part.

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