Intelligent Panic Disorder Treatment by Using Biofeedback Analysis and Web Technologies

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Abstract: The treatment of mental disorders has recently become a significantly important research issue in the medical science field. The treatment of mental illness through biofeedback therapy is fast becoming an important topic which can be basically defined as a combination method integrating biofeedback devices and self-help programs. With the advent and development of information and communication technologies, Internet is playing a crucial role in many healthcare applications. A number of research works on the integration of the Internet and mental healthcare have been proposed in recent years. Through cognitive behavioral therapy via the Internet, a considerable amount of time in treatment can be saved for patients and medical costs can be significantly reduced. This research aims at the development of an online treatment system for panic patients by combining biofeedback therapy and web technology. The system provides a more convenient communication between patients and medical professionals. The related information and crucial treatment provided by the medical professionals can be queried or downloaded online via a web-based interface by the patients independently. Moreover, managing functions are provided for the therapists and the hospital managers. The results of this research are expected to bring a pivotal impact on the healthcare industry with increased and enhanced levels of technology and services.

Keywords: biofeedback analysis, online mental therapy, panic disorder treatment, intelligent healthcare, data mining
1 Introduction

Due to the rapid development of lifestyle and industrialization in modern society, mental disorders have become more and more prevalent. Mental illnesses are mainly divided into major and minor disorders. Minor mental disorders are mainly anxiety and depressive disorders, such as generalized anxiety disorder, panic disorder, dysthymic disorder, and obsessive-compulsive disorder. However, the patients' cognitive function and reality testing are generally preserved. On the other hand, those with major mental disorders may show impaired cognitive function and poor reality testing. The most common major mental disorders are schizophrenia and bipolar disorder.

In mental disorders, panic disorder can be described as a chronic disease, and is also commonly found in the ER Department. The symptoms of panic disorders are not easily diagnosed. They are often diagnosed as heart attacks or other possible diseases, and the patients may have many unnecessary medical procedures. The mental symptoms of the patients with panic disorders are fear of losing control of themselves, derealization, depersonalization, and the feeling of impending death. The physiological symptoms also include dizziness, dyspnea, tachypnea, and palpitations. The patients will be very fearful and uncomfortable. The symptoms of panic disorder may recur unexpectedly, which make the sufferer feel highly distressed and apprehensive. Therefore, their behavior will blatantly obvious. They will endeavor to try and escape from the situations they feel terrified of. To avoid disastrous anxiety, patients may restrict their activity and ask others to accompany them. If the mental morbidity lasts too excessively, patients may develop...
depression and substance abuse disorder. These symptoms not only waste medical resources and delay time limitations for treatment, but also result in inconveniencing social and occupational functionalities. It has been demonstrated that the life quality of the victims of panic disorder is morbidly poor.

Since the development of electronic communication technology, the Internet, e-mail, and video conferencing have increasingly played fundamental roles in many healthcare applications. At the present time, a number of researches have integrated mental healthcare treatment with the Internet and have used it for the treatment of depression and anxiety disorders. In addition, there have also been researches applying the use of the Internet for the treatment of substance abuse disorders, such as smoking and alcoholism. The advantages of integrating cognitive behavioral therapies with the Internet are not only saving treatment time, but also reducing the cost of healthcare, and demonstrating good therapeutic efficacy.

In view of these salient attributes, in this paper, we aim at building an intelligent mental disorder treatment system with the integration of biofeedback therapy and web technologies. The contributions of this system are as follows. First, the system provides a convenient channel for communication between patients and medical staff. Second, the hospital staffs enable patients to query or download information via the Internet. Third, patients can upload their physiological data and self-rating scales to the database of the hospital via the Internet. Patients can use the system at home. By using this convenient Internet feature, medical resources can be efficiently saved. In the experiments section, we also employ the data to explore the possibility of giving mental healthcare with physiological data. We expect that the system can assist the prevention and treatment of mental disorders by monitoring the physiological data with real clinical verification.

For biofeedback measurements, we used a new device, named emotion ring, as shown in Figure 1 to record the patient’s finger skin temperature. Different to other biofeedback devices, the advantages of the emotion ring are compact size, easy to carry, ease of operation, and wireless data transmission. We applied online progressive muscle relaxation training combined with the emotion ring measuring to help patients learn how to relax themselves and alleviate the symptoms of panic disorder. Once the patients learn the somatic cues for relaxation and the method to obtain rapid relaxation, they were able to apply the methods and cues to relieve the symptoms of panic disorder. We used the proposed online therapeutic system for the patients to perform the treatment themselves at home. We also requested them to upload the biofeedback data via the system daily and whereby therapists could quickly manage patients' latest data. Furthermore, patients were asked to fill out the self-rating scales online and upload them to the database, so that the therapists could know the patients' mental status, judge their curative effect, and give them necessary feedback.

Figure 1 The biofeedback device: emotion ring

This paper is the first research for the system that integrates biofeedback therapy and the Internet. We expect the system can be used by the patients to practice biofeedback therapy at home. In this paper, we also constructed a complete biofeedback online therapy model, which was also composed of cognitive behavioral therapy, data transmission and storage, filling out necessary scales, and connection and interaction between patients and therapists via the Internet. The results are expected to increase the
convenience of psychotherapy, decrease the medical cost, be able to deal with more patients who need psychotherapy, and provide a beneficial application for public health in society and also academia.

The rest of this paper is organized as follows: In Section 2, we summarize the existing researches on panic disorders. In Section 3, we describe the proposed online treatment system for panic disorders in detail. The evaluation and results of our research are presented in Section 4. Section 5 is the conclusion of the paper.

2 Related Works

Panic disorder is encountered frequently in general medical practices and emergency services. The data from National Comorbidity Survey Replication of the United States showed the lifetime prevalence estimates are 3.7% of panic disorder without agoraphobia (panic disorder only), and 1.1% of panic disorder with agoraphobia (Kessler et al., 2006). The international lifetime prevalence rates of panic disorder ranged from 0.13% in rural village of Taiwan to 3.8% in the Netherlands (Somers et al., 2006). This disorder is rather debilitating to the sufferer, and even causes depression or suicide (Weissman et al., 1989). The life quality of the victims of panic disorder is dismal, and even worse than those with major depression (Markowitz et al., 1989). The victims of panic disorder also received more welfare or some form of disability compensation (Mendlowicz et al., 2000).

For public health, the optimal treatment for panic disorder is an important task to be dealt with. In clinical practice, two major modalities have been applied to its treatment: one is pharmacotherapy and the other is non-pharmacological psychotherapy. For psychotherapy, cognitive behavioral therapy is the main mode and has been proved to be effective for symptom management and prevention of recurrence for panic disorder (Roy-Byrne et al., 2006; Wetherell et al., 2005). Thanks to the advancement in computing and the Internet, computer-aided cognitive behavioral therapy has been employed for more than one decade. It is any computing system that aids cognitive behavioral therapy to make computations and treatment decisions (Marks et al., 1998). But computer-aided cognitive behavioral therapy should not only expedite communication or overcome the problem of distance; it consists of computation rather than replacing routine paper leaflets only (Marks et al., 2007).

Most Internet interventions for mental disorders are cognitive behavioral programs that are proposed as guided self-help programs on the Internet. Randomized controlled studies on the use of Internet interventions for the treatment of mental disorders are still scarce (Pull, 2006). From the limited literature it showed that computer/Internet-aided cognitive behavioral therapy was superior to waiting lists and placebos assignment across outcome measures, and the effects of computer/Internet-aided cognitive behavioral therapy were equal to therapist-delivered treatment across anxiety disorders. However, conclusions were limited by small sample sizes, the rare use of placebo controls, and other methodological problems (Reger and Gahm, 2009).

Treating panic disorder sufferers via the Internet is a rational concept, not only considering the issue of transportation of patients but also that of those suffering from agoraphobia. Up to date, publications about clinical trials of Internet-based cognitive behavioral therapy for panic disorder were mainly from Sweden, United Kingdom, and Australia. Carlbring et al. constructed a cognitive behavioral therapy treatment program consisting of stepwise intervention modules: psychoeducation, breathing retraining and hyperventilation test, cognitive restructuring, interoceptive exposure, exposure in vivo, and relapse prevention (Carlbring et al., 2001). The participants got significant improvement in all dimensions of measures. They further compared an Internet-based
treatment program with an applied relaxation program which instructed the participants on how to relax expeditiously and apply relaxation techniques to prevent a relapse into a panic attack (Carlbring et al., 2003). The applied relaxation condition has a better overall effect compared to the cognitive behavioral therapy program, and the effectiveness of the two groups was similar. Recent randomized trials demonstrated that Internet-based cognitive behavioral therapy for panic disorder could be as cogent as traditional individual cognitive behavior therapy (Carlbring et al., 2005; Kiropoulos et al., 2008).

3 Proposed Methods

In this paper, we integrate our mental disorder therapy system with the Internet to efficiently collect the biosignal data, the self-rating scales and the personal profiles of the patients with mental disorders. In this section, we describe the scenario and the functions of our proposed online therapy system.

3.1 User Scenarios

There are four kinds of users in this system: patients, therapists, hospital managers, and system managers. In the following, we explain the user scenarios in detail.

The Scenario of Patients with Mental Disorders: Patients with mental ailments use the finger temperature measurement system and upload the results to the databases daily. After measuring finger temperature, the patients also need to express their feelings and moods during the courses and their self-rating scores before and after the courses to their therapists for determining their current learning status. Otherwise, their daily courses are regarded as not complete. Either weekly or monthly, they need to fill out the self-rating scales which are provided by the therapists in the system. Incidentally, the patients can also query their own treatment records or see the suggestions which were provided by their therapists.

The Scenario of the Therapists: The therapists use the system to manage the data uploaded by patients. The data are composed of the finger temperature and the self-rating scales. By noting the patients' feelings and moods during the courses and the self-rating scores before and after the courses, the therapists can assimilate the patients' comprehension status and reply to any suggestions. When the patients login afterwards to the system, they can conveniently check the suggestions. Furthermore, the therapists can create new patients' accounts by themselves without going through the database managers. When a patient finishes the treatment procedure, the therapist can directly close this case in the online system.

The Scenario of the Hospital Managers: If a hospital manager is also a therapist, he/she can manage his/her patients like a therapist does in the system. Moreover, the hospital manager can also manage all therapists in the hospital via the system. The hospital managers can create new therapists' accounts by themselves without contacting the database managers.

The Scenario of the System Managers: The system managers do not actually need to use the system. They just manage and maintain it. They can create new accounts for hospital managers. However, since the treatment records cannot be made arbitrarily public, the system managers cannot see patients' treatment data.
The privileges of the users are shown in Table 1 and Figure 2. In the table and the figure, we can see the top management of this system is the system manager. He/She can create the accounts for the hospital managers. For each individual hospital, there is only one hospital manager handling all the therapists who use the system in the hospital. The therapists can manage all their own patients via the system.

<table>
<thead>
<tr>
<th>Login roles</th>
<th>Creatable accounts</th>
<th>Checkable Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>system managers</td>
<td>hospital managers</td>
<td>none</td>
</tr>
<tr>
<td>hospital managers</td>
<td>therapists, patients</td>
<td>therapists, patients</td>
</tr>
<tr>
<td>therapists</td>
<td>patients</td>
<td>patients</td>
</tr>
<tr>
<td>patients</td>
<td>-</td>
<td>themselves</td>
</tr>
</tbody>
</table>

Table 1  The privileges of the users in the system

Figure 2  Sketch map of login roles

3.2 System Description

In the first part of this section, we explain the methods of data transmission by the device, namely, emotion ring, which is used for measuring finger temperature in the system. In the second part, we also describe the functions of this system.

3.2.1 The techniques of measuring finger temperature

In the following, we describe the communication processes and methods between the emotion rings and the computers. First, the device driver of the emotion ring is installed. After installation, the MAC address of the emotion ring and the detected temperature will be transmitted from the emotion ring to the USB receiver once every second. When the USB receiver gets data, it simulates a COM port and transmits the data with 11 bytes. Table 2 is an example of the transmitted data. The first byte is fixed as “A3”. The second to the ninth bytes are the MAC address of the emotion ring. The last two bytes are temperature data. The first four MAC addresses of all emotion rings are all the same, “001CD902”. The received temperature data are ten times of the actual temperature.

<table>
<thead>
<tr>
<th>Preamble</th>
<th>MAC Address</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>A3</td>
<td>00 1C D9 02 00 00 00 3B</td>
<td>01 0A</td>
</tr>
<tr>
<td>1 Byte</td>
<td>8 Bytes</td>
<td>2 Bytes</td>
</tr>
</tbody>
</table>

Table 2  An example of the data transferred by the emotion ring
Title

The execution environment of the receiving end is Java applet. The basic libraries of Java do not support the input and output of the serial ports. User's Java environments will be detected and the libraries are created. The program for the receiver needs to search for a free COM port for receiving data. After receiving the data, the received information from the last eleven bytes to the last seven bytes are checked instead of from the first to the fifth bytes. The reason for this being if some errors occur during data transmission, the receiver may receive the data from the middle of the previous data instead of the first byte of the latest data. So we check from the last of the received data to avoid any error occurrence.

After checking the received data, the program acquires the data from COM port once a second, and output the number which is one-tenth of the last two bytes of data. Table 2 is an example of received data. The decimal in the last two bytes of the data, i.e., 010A, is 266, and its one-tenth is 26.6. This indicates the temperature which is detected at that time and is 26.6 °C. However, sometimes the USB receiver may not be given the data due to poor signaling strength. The emotion ring will be regarded as "not exist" when the program does not detect any data after three seconds.

3.2.2 System Workflow

First, users enter and login to the system website. Figure 3 is the screenshot of the patients' homepage. In this page, we remind the patient whether or not he/she has completed the daily course. If the patient does not complete it, the instructions in the related Web pages will lead he/she to do so. If there are some self-rating scales to be completed, it will also be mentioned in the homepage. In this way, the patients will not forget the routine task they need to complete on that day. If the patients want to query their previous finger temperature results records self-rating scales or view therapists suggestions, they can find them on the "records review" pages. On the page "contact therapist", the contact information for the therapists, e.g. e-mails, is provided for the patients.

Figure 3 Screenshot of the patients' homepage
The system flowchart is shown in Figure 4. As can be seen the patients can select the functions arbitrarily when they login to the system. For convenience in using the system and decreasing confusion for the users, the system details the options and procedures the user has to complete on that day. Through the guidance of the system, a patient may use the system as follows: First, he logs into the system and is informed by the homepage that he hasn’t completed the daily treatment course on that day. Then he completes it and uploads the temperature data, his emotional state during the course and the self-rating score before and after completing the course to the database. Next, he returns to the homepage and finds that he has a self-rating scale to complete, so he completes it. After finishing that day’s necessary tasks, he goes to the pages to see the suggestions which his therapist has given the previous day, the results of finger temperature and the self-rating scales are then uploaded that day. Finally, he logs out of the system.

As shown in Figure 4, the main functions of the system are measuring finger temperature, filling out self-rating scales, and uploading the data. The function of measuring temperature is integrated into the online therapy system. The patients can just click the “start measurement”, “pause measurement” or “end measurement” buttons, and can then easily complete the required tasks respectively. After the measurements, the data is uploaded to the database automatically by the system. This avoids any kind of confusion for the users from other various unconnected types of programs, such as one for measuring temperature and another for uploading data. The simplicity of the system promotes a willingness by the patients to participate in the system, which in turn popularizes it with the participating patients.

On the other hands, the hospital manager may also be a therapist, so some functions of the hospital manager and the therapist are the same. The main functions of the therapists are managing the patients, which entails viewing the data daily, replying to suggestions from the patients, viewing their periodical self-rating scales, filling out the patients’ self-rating scales, adding new patients, and so on. Besides the above functions, the main functions of the hospital managers are adding new therapists and the managing of them.

4 Experimental Evaluations

In this section, we introduce the sources, the designs, the results and discussion about the research.
Title

4.1 The Real Data for Experiments

In the experimental analyses, we use the data obtained from subjects from the department of psychiatry in a medical center in Taiwan. Eligible patients were instructed on how to use the system and the device, and any other pertinent matters which should be drawn to their attention by the psychiatrists. Then the patients filled out the consent form in order to participate in the research. After these, formalities were completed we could start collecting their data.

During the research, the patients were requested to fill out some self-rating scales for the therapists to periodically evaluate the patients' psychological states about panic disorders, life satisfaction and other conditions. The self-rating scales were filled out when the patients were performing self-treatments at home. The scales could reflect the patients' psychological and physiological states. The scales were chosen by the therapists from the view of psychological disorders and treatments. The chosen scales were as follows: the panic disorder severity scale (PDSS), the self-rating anxiety scale (SAS), the maudsley personality inventory (MPI), family APGAR (APGAR) and the MOS 36-item short-form health survey (SF-36).

In this research, we gave each patient a muscle relaxation course, i.e., muscle relaxation music, a biofeedback device, i.e., the emotion ring, and an account for login into the system. The patients were asked to practice the online treatment courses and how to upload the daily results. Then after every week or month, they were also asked to fill out the self-rating scales. The patients would also upload the scores of their emotions before and after the courses and also moods during the courses to the database. The therapists would review the data periodically and give the patients some feedback or suggestions if necessary.

In this research, the patients were divided into an experimental group and a control group. The patients in the experimental group did the courses as mentioned above, i.e., listening to muscle relaxation music and in the meanwhile measuring the finger temperature. On the other hand, the patients in the control group just listened to the muscle relaxation music without temperature measuring. The control group was mainly used for verification in the experiments.

During the research, we collected the patients' personal profiles, physiological data, and self-rating scales by different mechanisms. Among them, the physiological data was extracted and collected by the emotion rings as shown in Figure 1. After data collection, we utilized our data mining system for analyzing the data. Besides, we also utilized the online system for patients to upload the results of the self-rating scales. Before the analyses, we did the preprocessing on the collected data. Taking the self-rating scales for example, if we applied the data analysis techniques directly on the raw data, the processing time was very long or many errors could occur due to the mismatch of the data forms. Therefore, in this step, we focused on these data and processed essential data cleaning and integration. For example, the data could have been stored in another form, or the redundant and missing data had been deleted. Thus, the mining time is reduced and the accuracy of experiments is enhanced.

4.2 Data Analysis Methods

In this part, we describe the data analysis methods for the collected data, i.e., the patients' profiles, the self-rating scales, and the biofeedback data. We integrate the data mining techniques with the professional knowledge of the mental disorder to design methods of data mining analyses. We developed the following two data mining techniques for analyzing the curative effect and other factors.
4.2.1 Association Analysis of Curative Effect and Biofeedback Data

The first part of the proposed data mining analysis is the association analysis of the curative effect and the biofeedback data. The framework of this analysis is shown in Figure 5. We analyze the association between the biofeedback data and the curative effects. In this analysis, the finger temperature data is regarded as time series data. We apply the SAX algorithm (Lin et al., 2003) to transform the numerical data to sequence data. After data transformation, we apply sequential pattern mining (Pei et al., 2001) to the sequence data for finding sequential patterns. Then we apply the CBS algorithm (Tseng and Lee, 2005) for building classification models on curative effects. The results could be useful references in assisting the therapists in predicting the curative effects by the treatment conditions.

Figure 5  The framework of the analysis of the curative effect and the biofeedback data

4.2.2 Association Analysis of Curative Effect and Surrounding Factors

The second part of the proposed data mining analysis is the association analysis of the curative effect and the surrounding factors. The framework of the analysis is shown in Figure 6. In this analysis, we analyze the association of patients’ curative effects and the surrounding factors, such as the degree of family-care. The surrounding factors are the environmental factors which are potentially contained in the questions in the self-rating scales. There are many different factors in the selected self-rating scales. By these scales, we can know the patients’ degree of panic or the emotional state of their minds. We regard each question in the scale as a different attribute and the curative effects as the target class for analyzing the relationship of curative effects and other attributes.

Figure 6  The framework of the analysis of the curative effect and the surrounding factors

4.3 Experimental Results

In this section, we apply the above two data mining methods for analyzing real and synthetic data, respectively. We verify the effects of the two analyses by introducing two different experiments.
4.3.1 The Results of the Analysis of the Curative Effect and the Biofeedback Data

First, we communicate the experiment results of the analysis of the curative effect and the biofeedback data. In this section, we use real datasets as mentioned above. Before the analysis, we apply data preprocessing methods to prune the missing or error data. For a tuple whose temperature differs from the previous one by more than 2°C, it will be considered as an error and then pruned. Naturally, the temperature difference of a human will not be above 2°C in one second. This happens in the data because the battery of the device is flat or the patients interrupt the course, such as the emoting ring is suddenly removed from the finger. With regards to the curative effects, we use two types of scores for objectively and subjectively judging them. One is the self-rating scores which are determined by the patients themselves, and another is the curative effects which are determined by the patients’ therapists. We perform the following experiments for the following four conditions.

Experiment A. In this experiment, we take all patients' biofeedback data. We set the class for each tuple according to the patients' self-rating scores. If the scores after the courses are better than the scores before, we regard the treatment effects as "good"; otherwise, they are considered as "bad." The class values of the tuples in this experiment are just good or bad. We divide this data into training data and testing data with the ratio of 7:3. The experimental results are shown in Table 3. From Table 3 to Table 6, the column "inner testing" means the accuracy of the training data and "outer testing" means the accuracy of testing data. By looking at Table 3, we can see the overall accuracy is high, i.e., above 80%. It can be seen from this that the curative effects are highly dependent on the biofeedback data, i.e., the finger temperature of patients during the sessions. Furthermore, we can also appreciate that the biofeedback data can really reflect the patients' mental state, i.e., if the temperature is gradually declining, the patient is nervous, and conversely, if the temperature is gradually rising, the patient is relaxed. The results could be important for the therapists' diagnosis.

<table>
<thead>
<tr>
<th></th>
<th>Inner testing</th>
<th>Outer testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy</td>
<td>0.83</td>
<td>0.85</td>
</tr>
<tr>
<td>Precision of good</td>
<td>0.85</td>
<td>0.92</td>
</tr>
<tr>
<td>Recall of good</td>
<td>0.97</td>
<td>0.92</td>
</tr>
<tr>
<td>F-measure of good</td>
<td>0.91</td>
<td>0.92</td>
</tr>
</tbody>
</table>

Experiment B. In this experiment, we take all patients' biofeedback data. We set the class to each tuple according to the curative effect which is determined by the therapists. The therapists judge the patients' curative effects by not only the self-rating scores but also the biofeedback data, i.e., the curves of finger temperature, and the feelings and moods of the patients. There are three kinds of curative effects considered by the therapists: good, bad, and medium. In this experiment, we use the tuples with the class good and medium. We also divided the data into training data and testing data by 7:3. The experimental results are shown in Table 4. By Table 4, we can observe that the results are a little worse than Experiment A. This is because the therapists took into account not only the patients' biofeedback data but also the patients' emotional and mood state during the courses. These might cause some variants on the previous experimental results whose curative effects are judged by using only patients' biofeedback data.
Table 4  The results of Experiment B

<table>
<thead>
<tr>
<th></th>
<th>Inner testing</th>
<th>Outer testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy</td>
<td>0.81</td>
<td>0.70</td>
</tr>
<tr>
<td>Precision of good</td>
<td>0.90</td>
<td>0.86</td>
</tr>
<tr>
<td>Recall of good</td>
<td>0.86</td>
<td>0.92</td>
</tr>
<tr>
<td>F-measure of good</td>
<td>0.88</td>
<td>0.80</td>
</tr>
</tbody>
</table>

Experiment C. We take all patients' biofeedback data in this experiment. Similar to the previous experiment, we also set the class for each tuple according to the curative effect which is determined by the therapists. In this experiment, we use the tuples with the class good and bad. We divide the data into training data and testing data by 7:3 and 8:2. The experimental results are shown in Table 5. In Table 5, the results are better than Experiment B. We can see that it is easier to judge good or bad than good or medium because the differences in the former are larger than the latter.

Table 5  The results of Experiment C

<table>
<thead>
<tr>
<th></th>
<th>Inner testing</th>
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</tr>
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<tbody>
<tr>
<td></td>
<td>7:3</td>
<td>8:2</td>
</tr>
<tr>
<td>Accuracy</td>
<td>0.86</td>
<td>0.81</td>
</tr>
<tr>
<td>Precision of good</td>
<td>0.91</td>
<td>0.92</td>
</tr>
<tr>
<td>Recall of good</td>
<td>0.95</td>
<td>0.88</td>
</tr>
<tr>
<td>F-measure of good</td>
<td>0.93</td>
<td>0.90</td>
</tr>
</tbody>
</table>

Experiment D. In this experiment, we take a certain patient's biofeedback data for observing the differences between different datasets. We set the class to each tuple according to the curative effects which are determined by the therapists. We use the tuples with the class good and bad. We also divide the data into training data and testing data by 7:3. The experimental results are shown in Table 6. By Table 6, we can observe that the experiment results are worse than the above three experiments. This is because that there is too little data whose class values are bad in this patient's data. It causes the data bias problem and in turn the experiment results also become worse.

Table 6  The results of Experiment D

<table>
<thead>
<tr>
<th></th>
<th>Inner testing</th>
<th>Outer testing</th>
</tr>
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<tbody>
<tr>
<td>Accuracy</td>
<td>0.72</td>
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<td>Precision of good</td>
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<tr>
<td>Recall of good</td>
<td>0.75</td>
<td>0.6</td>
</tr>
<tr>
<td>F-measure of good</td>
<td>0.83</td>
<td>0.75</td>
</tr>
</tbody>
</table>

From the above four experiments, we can ascertain that the curative effects are highly dependent on the biofeedback data, i.e., the curves of finger temperature, for the patients with panic disorders. By using this system, we can better control the patients' status when they are performing the biofeedback therapies. In other words, we can know not only the patients' physical state but also their mental state when they are participating in the courses.

4.3.2  The results of the Analysis of the Curative Effect and the Surrounding Factors

In this part, we use synthetic data instead of real data due to the fact that real data for self-rating scales are too few to perform reliable experiments. In the synthetic data, we set some key questions, i.e., the questions which are most related to the curative effects, in
each scale by discussing with the therapists and set the value of the target class for each
tuple according to the results of the key questions. From the synthetic data, we want to
find the relationship between the curative effects and the key questions.

Although there are five scales in our system, two scales are just for correlating and
verifying the correctness of the others: SF36 and PDSS. If the patients give false answers
or complete the answers randomly in the forms, the false information will be checked in
the verification processes. The checked forms will then be regarded as invalid. Thus, only
the three scales were used which were higher depending on the curative effects: MPI,
APGAR and SAS in the following experiments. In these experiments, we simulate one
thousand patients filling in the forms over a period of one month in the system. The
amount of synthetic data of MPI, APGAR and SAS are 1000, 4000 and 7000 respectively
because for each patient’s scenario, he/she will fill the three scales once, four times and
seven times monthly in the system. Incidentally the results are measured by accuracy,
precision, recall, and F-measure. The definitions of precision, recall, and F-measure are
shown in Figure 7.

Figure 7 The definitions of precision, recall and F-measure.

<table>
<thead>
<tr>
<th>Predicted</th>
<th>False</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual</td>
<td>True</td>
</tr>
<tr>
<td>True</td>
<td>TP (true positive)</td>
</tr>
<tr>
<td>False</td>
<td>FN (false negative)</td>
</tr>
</tbody>
</table>

Precision = \( \frac{TP}{TP + FP} \)
Recall = \( \frac{TP}{TP + FN} \)
F-measure = \( \frac{2 \times (\text{Precision} \times \text{Recall})}{\text{Precision} + \text{Recall}} \)

The experiment results of the association analyses of the curative effects and surround
effects are shown in Figure 8. Figure 8 (a)-(f) show the results of MPI, APGAR and SAS,
respectively. In these figures, the meanings of Inner and Outer are the results of training
and testing data respectively. Besides, the meanings of A, P, R and F are the
abbreviations of accuracy, precision, recall and F-measure, respectively. From the
research experimental results, we can observe know that the accuracy for all is above
80%. It is shown that the relationships between the two factors are high. In Figure 8, we
can also see that the results of MPI are worse than SAS and APGAR. The reason for this
being are because the question numbers of the latter two scales are less than the former,
so the importance of each question in the latter two scales is higher than the former. On
the other hand, there are more question numbers in MPI. For each question in MPI, its
importance is lower than the question in SAS or APGAR. Therefore, the experiment
results of MPI are worse than the other two scales.

5 Conclusions and Future Works

In this paper, we have proposed a web-based online therapeutic system for panic disorder.
The contributions of our system are as follows. First, the system provides a convenient
channel for the communication of the patients and the hospital staffs. The hospital staffs
enable patients to query or download information via the Internet. The therapists and the
hospital managers can also manage their patients conveniently. Second, the patients can
measure their physiological data and fill out the self-rating scales for mental healthcare
via the system. Third, the patients' physiological data and self-rating scales can be
uploaded to the databases of the hospitals automatically. It shows from the results that the
biofeedback and the rating scale data are useful for judging the therapeutic effects in panic disorder patients.

Although the proposed system is convenient for the users, the patients who could not access computers and the Internet or those who did not know the manual procedure of biofeedback measurement and data transmission could not derive the benefit still. Thus, for future work, we will apply the system to mobile platforms such as mobile phones and PDAs so that the users may use this system more conveniently and ubiquitously.

**Figure 8** The experimental results of MPI, APGAR and SAS

![Figure 8](image_url)

**References**


