

A virtual therapist that responds empathically to your answers

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Abstract. Previous research indicates that self-help therapy is an effective method to prevent and treat unipolar depression. While web-based self-help therapy has many advantages, there are also disadvantages to self-help therapy, such as that it misses the possibility to regard the body language of the user, and the lack of personal feedback on the user responses. This study presents a virtual agent that guides the user through the Beck Depression Inventory (BDI) questionnaire, which is used to measure the severity of depression. The agent responds empathically to the answers given by the user, by changing its facial expression. This resembles face to face therapy more than existing web-based self-help therapies. A pilot experiment indicates that the virtual agent has added value for this application.

Keywords: Virtual agent, Self-help therapy, Emotion modeling

1 Introduction

Self-help therapies have been investigated for several decades. Self-help therapy started with bibliotherapy, in which clients follow a therapy from a book. Previous research indicates that this is a very effective form of therapy; e.g., a meta-analysis by Cuijpers [7] concluded that bibliotherapy in unipolar depression is an effective treatment modality, which is no less effective than traditional individual or group therapy.

The advent of new communication technologies, like internet and videoconferencing, can also assist in the field of mental healthcare. Since the last decade, a lot of self-help programs have been delivered through the internet [5], [6], [12]. Several previous studies concluded that self-help therapies are useful and efficient in reducing mental health problems convincingly (e. g., [7], [12]). Compared to traditional therapy methods, web-based self-help may be more efficient and less expensive [4], [9].

Web-based self-help therapy can also be a solution for people who would otherwise not seek help, wishing to avoid the stigma of psychiatric referral or to protect their privacy [13]. The majority of persons with a mental disorder in the general population do not receive any professional mental health services (an estimated 65%) [4]. In many occupa-

tions, such as the police force, the fire service and farming, there is much stigma attached to receiving psychological treatment, and the anonymity of web-based self-help therapy would help to overcome this [11]. Also many other people feel a barrier to seek help for their problems through regular health-care systems; e.g., in a study by Spek et al. [12] about internet-based cognitive behavioural therapy for subthreshold depression for people over 50 years old, many participants reported not seeking help through regular health-care systems because they were very concerned about being stigmatised. Patients may be attracted to the idea of working on their own to deal with their problems, thereby avoiding the potential embarrassment of formal psychotherapy [13]. Self-help therapy can also be offered to patients while they are on a waiting list, with the option to receive face to face therapy later, if required [11].

However, there is also critique on internet-based self-help therapy. Drop-out rates from self-help therapy can be high, especially when the use of self-help is unmonitored by a health care practitioner [13]. A wide range of drop-out rates for bibliotherapy have been estimated: from about 7% [7] up to 51.7% [12]. People may miss personal feedback when performing self-help therapy, which might decrease their motivation. By making self-help therapy more similar to face to face therapy, it can become a more personal and entertaining experience, which might decrease drop-out.

Several self-help therapy programs are already available on the internet. Two well-known examples of CBT (Cognitive Behavioural Therapy) programs are 'BluePages' and 'MoodGYM' [5]. BluePages gives information about the symptoms of depression whereas MoodGYM is designed to prevent depression [5], [6]. However, none of the existing online self-help therapies include a virtual agent that provides a kind of face to face assistance.

There have already been developed several agents in the health-supporting domain. For example, [3] describes a virtual agent that explains health documents to patients.

This study presents an application for performing the Beck Depression Inventory questionnaire [2]. The application is equipped with a virtual agent that responds empathically to the responses of the user. As the virtual agent is emotionally responsive to the answers given by the user throughout the questionnaire, the experience should resemble face to face therapy more than a similar application without a virtual agent.

2 The application

In the application, the user performs the BDI questionnaire [2]. The main goal of the BDI is to measure the characteristic attitudes and symptoms of depression. The BDI is a self-report inventory that consists of 21 multiple-choice questions, and is generally used for measuring the severity of depression. Every question has at least four answer options ranging in intensity from 0 to 3.

The virtual agent asks the questions to the user, and the user selects the appropriate answer from a given drop-down box. This virtual agent has a certain emotional state, consisting of two emotions: happiness and empathy. According to Eisenberg [8], empathy is "*An affective response that stems from the apprehension or comprehension of another's emotional state or condition, and that is similar to what the other person is feeling or would be expected to feel.*" Because in this application a depression questionnaire is conducted, which means empathy concerns rather sad things, showing empathy

consists of showing sadness. If during the questionnaire the user appears to be more depressed the virtual agent will show more sadness, expressed by a relatively sad facial expression. On the other hand, if the user appears to be completely fine, the agent will show a relatively happy facial expression. When the webpage is loaded for the first time, the original emotional state of the virtual agent is loaded, which is a calm emotional state, with very little sadness and an average level of happiness.

2.1. The emotion model of the agent

The virtual agent responds empathically towards the user, by showing the right facial expressions on the answers given by the user. In consultation with clinical psychologists, we defined an impact of these answers as a real number in the domain $[-1, 1]$ on the emotions of the virtual agent, represented by a real number in the domain $[0, 1]$. Further we defined in consultation with the clinical psychologists how the agent should behave towards the users using these impacts. The impacts are used to detect how the user is feeling. When the user gives a lot of answers that indicate he or she is not feeling well, the agent should show empathy, by showing a sad facial expression, without showing any happiness. When the user is feeling fine, the agent should show a neutral, calm facial expression, with some happiness and no sadness. Because it would be undesirable if the emotions of the agent suddenly shift from very sad to very happy or vice versa, with any change in emotions, the old levels of the emotions are taken into account. If the answers of the user have no impact on the emotions of the agent, its facial expression should slowly return to the original emotional state it had at the start of the application. We have developed the following formula that meets the requirements as described above:

$$\begin{aligned} \text{New_emotion} &= \text{Old_emotion} + \text{Decay} + \text{Change} \\ \text{Decay} &= (\text{Original_emotion} - \text{Old_emotion}) * \text{Decay_factor} \\ \text{Change} &= \zeta * \text{Impact} / (1 + (\text{Original_emotion} - \text{Old_emotion}) * \text{Impact}) \end{aligned}$$

New_emotion can be calculated by taking the old emotion, and adding decay and change. Here Old_emotion is the emotion of the virtual agent before the formula is applied. Decay is the size of the decay effect (i.e., how quickly the emotion will move towards the original emotion if the user response has no impact). Change is the change of the emotion of the virtual agent, according to the impact of the answer given by the user.

Decay is calculated by subtracting Old_emotion from Original_emotion, and multiplying the result with the Decay_factor. In this formula, Decay_factor is a variable that determines the size of the decay effect, which is taken 0.1 in this paper. Original_emotion is the emotion of the virtual agent at the start of the application.

Change is calculated by multiplying the impact of the answer given by the user with ζ , and dividing the result by $1 + (\text{Original_emotion} - \text{Old_emotion}) * \text{Impact}$. In this formula, ζ is a variable that determines the speed with which the answers given by the user can modify the emotions of the virtual agent. Dividing Impact by $1 + (\text{Original_emotion} - \text{Old_emotion}) * \text{Impact}$ manages that when the current emotion of the agent deviates more from the original emotion the agent had at the start of the application, and the answer given by the user pushes the emotion of the agent even further away from the original

emotion, the change will be relatively smaller as when the user's answer would push the agent's emotion back towards the original emotion with the same impact.

The emotions of the agent during two scenarios are shown in Figure 1. In this figure, along the x-axis the time is given and along the y-axis the levels of emotions are given. The pink line shows happiness and the blue line shows sadness. In scenario 1, the agent interacts with a severely depressed user, while in scenario 2 the agent interacts with a user who scores average on feelings of depression.

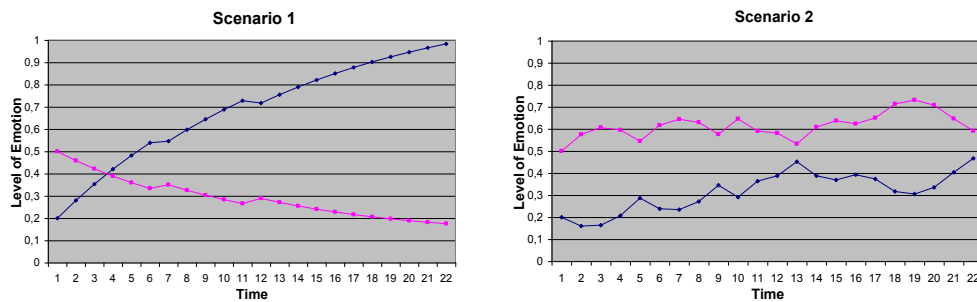


Fig. 1. The emotions of the agent during scenario 1 and scenario 2

As can be seen in Figure 1, initially the virtual agent has a very small level of sadness (0.2) and an average level of happiness (0.5). Each time point the virtual therapist asks a question to the user and gets an answer. This answer affects the emotions of the agent. The user in scenario 1 is severely depressed, coming to a final score of 61 on the BDI questionnaire. During the questionnaire, the agent notices this, which increases her level of sadness and decreases her level of happiness. This results in the agent showing empathy towards the user by means of a sad facial expression.

In scenario 2, the user got an average score on the BDI questionnaire (33). This means the user scores average on feelings of depression. In Figure 1, the different emotional reactions of the agent on the answers of the user in scenario 2 can clearly be seen. On answers that indicate the user is depressed, such as the answer just before time point 5, the agent's level of sadness increases, and the agent's level of happiness decreases. On the other hand, on answers that indicate the user is not depressed, such as the answer just before time point 6, the agent's level of sadness decreases, and the agent's level of happiness increases. At the end of the questionnaire, the agent shows a facial expression with an average level of both sadness and happiness.

2.2 The resulting website

For creating the virtual agent, we used Haptেক's peopleputty software [10]. Through this program we created the face of the virtual agent. Further, we created nine different emotional states using the sliders 'happy' and 'sad' given by the software; one for each possible combination of the three levels of the emotions happiness and sadness (showing empathy). We created a webpage for the BDI questionnaire, on which the virtual agent was embedded as a Haptেক player. We used JavaScript [1], a scripting language, in com-

bination with scripting commands provided by the Haptik software [10], to control the Haptik player within a web browser.

We performed a pilot experiment to test whether the virtual agent has added value for the application. To recruit participants, we invited people by sending an e-mail with a link to the website. The first page of this website does not show the virtual agent, and contains 8 demographic questions. The next page contains the 21 questions of the BDI questionnaire. The virtual agent is shown on top of this page. Before the first question, the agent introduces itself, and states that it will guide the user through the questionnaire. Instead of showing all the questions in a form, only one question at a time was shown, to let the application more resemble face to face therapy. Each question is shown in a text area below the virtual agent. Below the question, there is a dropdown-box from which the user can select an answer.

Because some of the possible participants were Dutch, we created a Dutch, as well as an English version of the website. In the English version, the virtual agent asks the question using speech. Because at the moment of this study, we did not have a Dutch speech synthesis engine available that included lip-syncing, in the Dutch version the question was only shown in the text area below the virtual agent. We used this shortcoming of the Dutch version to investigate the added value of speech in this application.

Each time the user selected an answer from the drop-down box, the virtual agent changed its emotional state depending on the calculated values of the emotions, as described in section 3.1. Each answer has a score, as described in Section 2, and during the questionnaire these scores are accumulated to calculate the final score. When the user presses the submit button, it proceeds towards the next page, where the virtual agent gives feedback about the final score of the user on the questionnaire, showing an appropriate facial expression. When the final score was below 16, the virtual agent indicates that the user is less depressed as average and shows a facial expression with a low level of sadness and a medium level of happiness. When the user scores between 16-41, the virtual agent indicates that the user scores average on feelings of depression and shows a facial expression with a medium level of sadness and a low level of happiness. When the user scores above 41, the virtual agent indicates that the user scores high on feelings of depression and shows a facial expression with a high level of sadness and a low level of happiness. If the user responded that he or she considers committing suicide, the agent stringently advises the user to contact his or her general practitioner.

After receiving the feedback, the user clicks a button to proceed to the next page, which contains the evaluation form. This page consists of 5 questions about the virtual agent, such as whether the user prefers performing the BDI questionnaire with or without the virtual agent. The virtual agent itself is not shown on this page, to prevent the user from giving socially desirable answers towards the agent.

3 Experiment

We have performed a pilot experiment to test whether the virtual agent has added value for this application.

Participants. The participants were recruited by sending an e-mail with an invitation to participate in the experiment. The participants could choose between a Dutch and an English version of the questionnaire. 28 participants completed the experiment, of which 16 the English, and 12 the Dutch version.

Procedure. First the participants entered some demographical information in a web-form, without the virtual agent. Next the application with the virtual agent was loaded, and the participants performed the BDI questionnaire. When the questionnaire was finished, the participants received feedback from the virtual agent about their result. In the English version, the question was shown in a text area below the agent, and the agent additionally asked the questions to the participants using speech. In the Dutch version however, the virtual agent could not speak, and the text was only shown in the text area below the agent. Finally, the participants filled in an evaluation questionnaire, without the virtual agent present to prevent socially desirable answers towards the agent. The complete procedure can still be performed at [14].

Results. The participants evaluated on an eight-point scale whether they thought the virtual agent was friendly, interested, trustworthy and kind. In both the English and the Dutch version, for all properties, the participants scored the agent just above moderate, as can be seen in Table 1. No statistical differences were found between the English version with voice, and the Dutch version without voice.

Table 1. The score of the virtual agent on several properties on an eight-point scale.

	English		Dutch	
	M	SD	M	SD
Friendly	4.75	1.98	4.91	1.30
Interested	4.50	2.13	4.00	1.95
Trustworthy	4.31	1.66	4.27	1.56
Kind	4.75	1.69	4.55	1.44

Further, the participants answered the question “If you were to administer the same questionnaire, would you rather do this with or without virtual interviewer?” on the evaluation form. For the English version, with speech, 81% of the participants preferred to perform the questionnaire with the virtual agent (sign test, $p = .021$). However, for the Dutch version, without speech, only 64% of the participants preferred to fill in the questionnaire with the virtual agent (sign test, $p = .55$).

The participants were asked to explain their answer in an open question. On this question people gave various responses, but a response that came back several times was that with the virtual agent, it “feels more personal” and that it “feels friendlier”. Participants also indicated that it was more fun to perform the questionnaire with the virtual agent. This indicates that the virtual agent makes it more attractive and entertaining to perform the questionnaire, and adding the virtual agent to a self-help application might decrease drop-out of the self-help therapy.

Participants that preferred to perform the questionnaire without a virtual agent gave as reasons for this that the agent was still too “cold and computer-like”, and with the Dutch version, without speech, that the agent did not have any added value.

The responses on the open question “How do you think the virtual interviewer should be improved?” indicated that there is still a lot of work to do. In the Dutch version, a lot

of participants responded that the agent should speak, while in the English version many participants responded that the voice of the agent should be friendlier. In both versions many participants responded the agent should give feedback on each answered question.

4 Discussion

This study presents a virtual agent that guides the user through a questionnaire about depression. The agent responds empathically to the answers given by the user, by changing its facial expression.

A pilot experiment has been performed to test the applicability of a virtual agent in this application. Due to time limitations, the way of recruitment of the participants was not ideal, and the participants are probably not a very good representation of the target group of online self-help applications. When the application has been improved, an extensive validation will need to be performed before it can be used in practice. However, the experiment has led to some interesting results that can be used to determine a direction for further research.

In both the English version, with speech, and the Dutch version, without speech, the participants found the agent moderately friendly, interested, trustworthy and kind. Further, although there were not many participants, an interesting statistical significant result was found. For the English version, the amount of participants who preferred to perform the questionnaire with the virtual agent was significantly bigger than the amount of participants who preferred to perform the questionnaire without the virtual agent. For the Dutch version also more participants preferred to perform the questionnaire with the agent than without, but this result was not significant. However, none of the participants appeared to actually be depressed, and the agent thus will not have shown much obvious empathic expressive behaviour. In the Dutch version of the application, without speech, this means the participants just saw a rather passive face above the questions. Given this information, and that there were only 12 participants, it is not very surprising that for the Dutch questionnaire, the amount of participants that preferred performing the questionnaire with the agent was not significantly bigger than the amount of participants that preferred performing the questionnaire without the agent.

Taking into account many improvements can still be made to the application, the results described above are very promising, and motivate further research in this direction. The response of a participant that he did not feel shy of the virtual interviewer as he would with a real one further indicates nicely the use of this kind of applications. For people who feel uncomfortable with undergoing face-to-face therapy and therefore choose not to seek help, an application like this can be a nice solution.

As also indicated by the responses in the experiment, many improvements can still be made to the application. As pointed out by many participants in the open questions, the agent should provide appropriate feedback after each answer on a question. This should increase the humanness of the agent, enhancing the feelings of a personal, realistic experience during the questionnaire.

Another possible point of improvement is the voice of the agent. The fact that with the Dutch version, without speech, the amount of participants that preferred to perform the questionnaire with the virtual agent was not significantly bigger than the amount of participants that preferred to perform the questionnaire without the virtual agent indicates

that this is an important issue. Moreover, in the open questions, many participants gave responses that indicated that speech should be added (in the Dutch version) or improved (in the English version). Since the application should ultimately also be available for Dutch speaking users, possibilities for adding Dutch speech synthesis including lip-synching should seriously be considered. Also possibilities to create a friendlier voice that is able to show emotions should be considered.

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