

Relationship between Mood Improvement and Questioning to Evaluate Automatic Thoughts in Cognitive Restructuring with a Virtual Agent

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Abstract—Cognitive restructuring is a therapeutic technique of cognitive behavior therapy that helps convert negative automatic thoughts to balanced thoughts. Automatic thoughts can be converted by the patient/participant’s own objective evaluation from a different perspective. Human therapists ask questions intending to guide the evaluation of automatic thoughts more effectively. Virtual agents, as therapists, have a great potential to support cognitive restructuring. We investigated how a virtual agent could affect the participant’s mood when asked questions to evaluate automatic thoughts in cognitive restructuring. We implemented a virtual agent that performs scenario-based dialogue with two types of dialogue scenarios: with and without questions to evaluate automatic thoughts. We conducted a dialogue experiment with 20 healthy graduate students and divided them into two groups of ten, finding that the participant’s negative mood significantly improved when the virtual agent asked questions to evaluate the automatic thoughts. Furthermore, the number of helpful questions was significantly correlated with the degree of mood change ($\rho=0.81$). The results suggest that it is important to provide appropriate questions for cognitive restructuring and that the number of helpful questions reflects the dialogue’s effectiveness.

Index Terms—cognitive restructuring, automatic thought, well-being, virtual agent

I. INTRODUCTION

Cognitive behavior therapy (CBT) examines biased unhelpful thoughts and seeks solutions to current problems [1]. The effectiveness of the CBT conducted by virtual agents have been confirmed in previous researches [2]. Such empathic systems could be applied in various fields of application (e.g., therapeutic assistance). Several types of agent dialogues have been developed, such as text-based dialogues in the style of messaging apps [3]–[6] and CG animated virtual agents [7]–[9]. CG animated virtual agents have the advantage of providing face-to-face multimodal interaction and are expected to promote engagement with participants with face-to-face interaction [10]. Besides, some studies on virtual agents based on psychiatric care reflect participant states’ estimation from verbal and non-verbal information in the training contents

[11]. A previous work [9] confirmed its effectiveness of CBT dialogue with a virtual agent for better mood improvement. Although evaluations of the use of virtual agents for CBT have been conducted, it is still not clear which parts of the dialogue content are effective. Automatic thoughts are thoughts or interpretations that automatically occur as a response to a situation. One of the important points of CBT is identifying automatic thoughts and evaluating them. Therapists ask various fact-finding questions to prompt patients to evaluate and modify their automatic thoughts.

We hypothesized that evaluating and modifying automatic thoughts would affect the effectiveness of the virtual agent’s dialogue in questioning. Our aim is to investigate the effect of questions in the dialogue of the CBT. We focus on cognitive restructuring, one of the central techniques in CBT, which examines biased unhelpful thoughts and seeks solutions to current problems [1]. In cognitive restructuring, patients perform what is called evaluating automatic thoughts. Cognitive restructuring often uses a worksheet called thought record and has been widely used in cognitive restructuring with therapists and personal use. A thought record was originally proposed by Beck et al. [1], and an updated version by Greenberger’s thought record [12] was also widely used. The main change between Beck’s and Greenberger’s thought record is the inclusion of questions, called Socratic questioning, that evaluate for and against automatic thought. The questions are taken from [1] and can be used broadly for general automatic thoughts. This paper compares mood improvement effects with and without evaluating automatic thoughts in cognitive restructuring with a virtual agent.

II. METHOD

A. Virtual Agent Architecture

We used a CG animated virtual agent, named “Shibata” (Fig. 1). We used a virtual agent platform, Greta [13], and modified it by Tanaka et al [14] for Japanese text-to-speech, lip-synching, and Japanese-style animation. We used default

TABLE I
SCENARIO OF UTTERANCES SPOKEN BY THE VIRTUAL AGENT.

No.	Item	Sentence (V means a virtual agent, P means a fictional participant.)
Q1	Situation	V: <i>Hello, my name is Shibata, and I am a therapist. Come join me in training to face your worries. Is there anything that's been bothering you lately that's been difficult to deal with or to face? Please tell me something that you think is painful or burdensome.</i> P: <i>Although I sent my friend an email, I haven't gotten a reply.</i>
Q2	Mood	V: <i>How did your mood change at that time?</i> P: <i>I'm so sad.</i>
Q3	Mood score (0 to 100%)	V: <i>How would you describe the intensity of your mood from 0 to 100?</i> P: <i>75.</i>
Q4	Question to identify automatic thoughts	V: <i>What thoughts came to your mind at that time?</i> <i>For example, "I am hated from my coworkers.", "My father is an ignoramus.", or "I'll be fired from my job".</i> P: <i>He hates me.</i>
Q5	Check if there are other automatic thoughts	V: <i>I see. Is there anything else? If you say everything you can think of, please say, "this is all."</i> P: <i>This is all.</i>
Q6	Question to evaluate and modify an automatic thought: Set up automatic thought for the agenda	V: <i>What is the strongest thought that comes to your mind?</i> P: <i>I'm hated.</i>
Q7	Question to evaluate and modify an automatic thought 1	V: <i>If your automatic thought is true, what evidence do you have to support this?</i> P: <i>In fact, I hadn't received a reply even after one night.</i>
Q8	Question to evaluate and modify an automatic thought 2	V: <i>If your automatic thought is not true, what evidence do you have to support this?</i> P: <i>My friends haven't told me they don't like me to my face yet.</i>
Q9	Question to evaluate and modify an automatic thought 3	V: <i>Besides your automatic thoughts, is there an alternative explanation?</i> P: <i>The email was not urgent, and no particular damage has been done.</i>
Q10	Question to evaluate and modify an automatic thought 4	V: <i>What's the effect of your believing automatic thought?</i> P: <i>I'll avoid getting involved with her.</i>
Q11	Question to evaluate and modify an automatic thought 5	V: <i>I see. So, what's the most realistic outcome?</i> P: <i>She may not be interested in me, but that doesn't mean she doesn't like me.</i>
Q12	Question to evaluate and modify an automatic thought 6	V: <i>I see. If your friend was in the situation and had this thought, what would you tell him or her?</i> P: <i>Why don't you wait for a response without taking it too seriously?</i>
Q13	Question to evaluate and modify an automatic thought 7	V: <i>What action would you do about your automatic thoughts?</i> P: <i>I'm going to take the reply easy and wait.</i>
Q14	Question to evaluate and modify an automatic thought: Balanced thought	V: <i>In addition to the automatic thoughts you mentioned, maybe you can find another idea. If you think of a new thought, try to connect them to your automatic thoughts with "but...".</i> P: <i>I think the fact that he hasn't responded means that she doesn't like me. But I'm not sure yet, so I'm going to take it easy and talk about the e-mail directly when I see her again.</i>
Q15	Mood score after change (0 to 100%)	V: <i>How has the intensity of your original mood changed? Express it on a scale from 0 to 100.</i> P: <i>40.</i>
[End]	Concluding a session	V: <i>If it's different from the beginning, that suggests that you organized my thoughts well. That's it for today. Thank you for your hard work. Please feel free to call again.</i>

parameters for its speech, such as speaking rate and voice pitch. It has a neutral facial expression setting. Shibata outputs spoken language and the participant inputs spoken natural language through a headset microphone. Our virtual agent automatically recognizes the participant's response by voice and takes turns.

B. Dialogue Scenario

Table I shows our dialogue scenario.

1) *Questioning to Identify Automatic Thoughts*: It is known that, in cognitive restructuring, patients sometimes fail to identify automatic thoughts. This is because automatic thought is a concept that is not usually recognized. We began our investigation of this guiding function by investigating the percentage of failures to identify automatic thoughts in the cognitive reconstruction method with virtual agents. In this investigation, we used a dataset collected in a previous work [9]. From the dialogue between the virtual agent and 36 participants, we extracted participant response sentences about automatic thoughts and labeled whether a medical doctor considered these sentences as automatic thoughts or not. The

results showed that 23 out of 36 participants were unsuccessful in identifying automatic thoughts. Therefore, it became clear that virtual agents must guide users in the identification of automatic thoughts.

Dialogue control with a classifier is performed in Q6. We automated the guide to identify an automatic thought by the following procedure.

- 1) Determine if a machine learning model identified an automatic thought.
Success: Move to the next item.
Unsuccess: Ask a question to guide identifying an automatic thought and have a participant answer again.
- 2) **Unsuccess**: Make a judgement with the automatic thought classifier. If it is unsuccessful again, provide another hint.

If the participant does not identify the automatic thought, the virtual agent gives one hint and asks the participant to answer again (e.g., *So, what did you think about yourself when you were in that situation?*). There are six hints in total, and up to six unsuccessful attempts to identify the automatic thought



Fig. 1. Shibata, our virtual agent for dialogue based on CBT

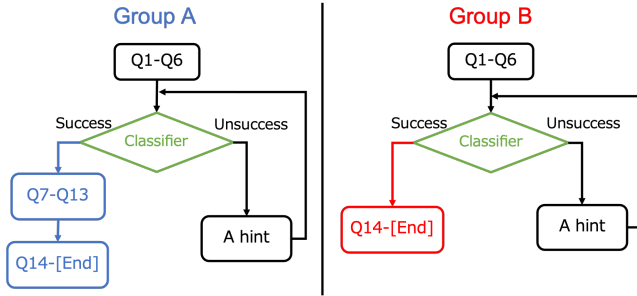


Fig. 2. Dialogue flow of Group A and Group B.

will be handled. Six hints will be given to all participants in the same order. If the participant fails seven times, they are forced to proceed to the next item. The hints are taken from Beck et al. [1].

The classification model was newly implemented in this study. The labeled data set [9] was used for test data ($n=36$). We used 33 sentences on automatic thought from a home medicine book by Greenberger et al. [12] for training data. In order to practice the distinction between automatic thoughts, situations, and moods, Greenberger et al. [12] provides a classed list of the three ways: automatic thoughts (e.g., *I am always going to feel this way., I will never be cured.*), situations (e.g., *Talking to a friend on the phone., Driving in my car.*), and moods (e.g., *Nervous., Sad.*). We labeled only automatic thoughts as positive among the three classes. The feature extraction methods used for the classifier in this paper are term frequency-inverse document frequency (TF-IDF). TF-IDF calculates importance by considering words that are common in the document library and words that are not. In the calculation of TF-IDF, we used MeCab morphological analyzer¹ for tokenize. For vectorization, we counted only the vocabulary in the training data. We used TF-IDF as a feature set. The classifier algorithm was a support vector machine (linear kernel). As a result, precision was 0.800 and, the f1-score was 0.833. We used this model in our study to guide the identification of automatic thoughts.

2) *Questioning to Evaluate and Modify Automatic Thoughts*: We prepared questions to evaluate and modify automatic thoughts using 9 questions Q6 to Q14 in Table

I. In this study, we prepared two dialogue scenarios: one which asked all the questions and one which left out questions Q7 to Q13. Our hypothesis of the experiment is that evaluating automatic thoughts improves mood. In the experiment, we prepared these seven questions to guide the evaluating automatic thoughts and asked them in round-robin, assuming that one would be effective for the participant. To clarify the hypothesis, we compared two groups (Fig. 2): Group A: a scenario with questions to evaluate an automatic thought; Group B: a scenario without questions to evaluate an automatic thought.

C. Experimental Evaluation

1) *Participants*: We recruited 20 healthy graduate students as participants, with 10 in Group A and 10 in Group B. The research ethics committee of Nara Institute of Science and Technology reviewed and approved this experiment (reference number: 2019-I-24-2). Written informed consent was obtained from all participants before this experiment. We also confirmed that the participants had no severe depressive tendencies based on the Kessler Psychological Distress Scale (K6) [15]. K6 is converted to a scale of 0 to 24 (six questions each coded 0 to 4 and summed), with a score of 13 or higher being the cutoff point for assessing the prevalence of severe mental illness. K6 score for Group A was mean (M)=3.90, standard deviation (SD)=4.04 and Group B was $M=4.30$, $SD=2.83$. There was no significant difference in K6 scores between the two groups.

2) *Experiment Procedure*: The same procedure was applied for the two groups. To begin, the participants read a leaflet explaining CBT². This leaflet is available to the public and is designed for both clinical and general public use. We then explained how to use our virtual agent. The experiment was conducted using a desktop personal computer.

3) *Mood Score Rating*: Participants were asked twice about their negative mood intensities for their *mood score*. The first was Q3, and the second was Q15 of the questions in Table I. The moods that the participants described in this dialogue are controlled to be negative moods only, such as anxious, depressed, sad, inferior, anger. We uniformly lumped all such feelings under the rubric of negative moods and only evaluated them by mood scores to focus on the changes themselves. Based on Persons et al. [16], we calculated the mood change using the following formula:

$$Mood\ change = \frac{(Mood\ score\ at\ beginning) - (Mood\ score\ at\ end)}{(Mood\ score\ at\ beginning)} \quad (1)$$

III. RESULTS

A. Mood Change through Interaction

In Group A, the results were as follows: mood score at the start was $M=54.5$, $SD=20.6$; mood score at the end was $M=32.0$, $SD=17.5$; mood change was $M=0.41$, $SD=0.23$. In

¹<https://taku910.github.io/mecab/>

²<https://www.cbtjp.net/downloads/skillup/pdf/>

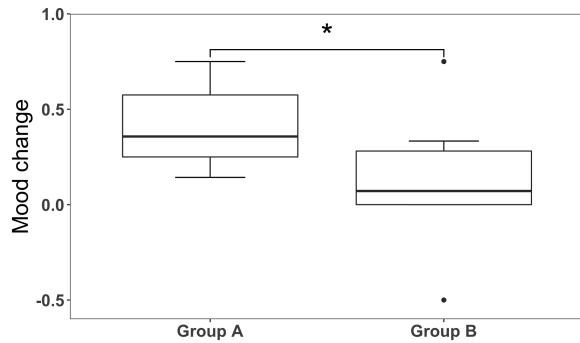


Fig. 3. Boxplot of mood change in mood score between Group A and Group B (*: $p < 0.05$).

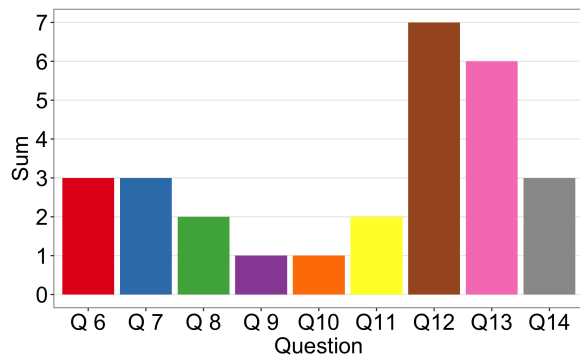


Fig. 4. Distribution of helpful questions (n=10, multiple answers possible).

Group B, the results were as follows: mood score at the start was $M=42.8$, $SD=26.5$; mood score at the end was $M=32.2$, $SD=18.0$; mood change was $M=0.13$, $SD=0.32$. Fig. 3 shows the improvement in negative mood in the two groups. This result shows that the questioning to evaluate automatic thoughts significantly affected the improvement in the negative mood score ($p=0.037$, Hedge's $g=0.97$). There was no significant difference in mood intensity between the two groups at the beginning and end of the study.

B. Distribution of Questions that Participants Felt Helpful

Group A evaluated the questions from Q6 to Q14 in Table I that they felt helped them discover new ideas. At the end of each participant's dialogue, a questionnaire containing the virtual agent's questions was presented. The participants rated each question in two classes: helpful or unhelpful. Fig. 4 shows the distribution of the questions that were answered as helpful. As a result, Q12 and Q13 were rated as helpful by the most participants, while Q9 and Q10 were rated as the least useful. One of the reasons for this result is the difference in the intention of the questions: Q9 and Q10 asked the participants to dig deeper into automatic thought. On the other hand, Q12 and Q13 were intended to examine automatic thought from a new perspective. This suggests that questions that change the participant's perspective can contribute more to the modification of the automatic thought.

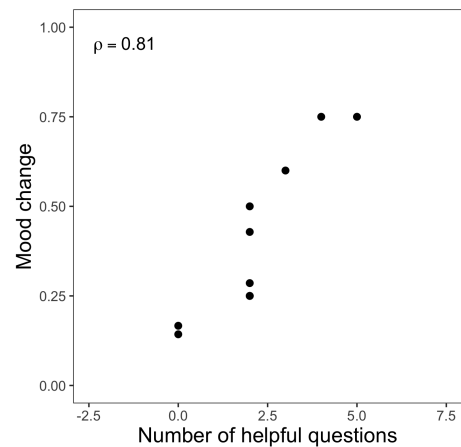


Fig. 5. Scatter plot between helpful questions and Mood change.

C. Correlation between Mood Score and Number of Helpful Questions

We investigated the correlation between the mood score and the number of helpful questions for Group A in the evaluating automatic thoughts. Each participant answered one questionnaire after the dialogue. The questionnaire is an evaluation of the questions from Q6 to Q14 conducted by the virtual agent. Participants asked yes or no if they felt helpful for each question. The results showed that there was a strong correlation between the number of helpful questions and the mood change ($\rho=0.81$, $p=0.005$) (Fig. 5). There also was a correlation between the number of helpful questions and the mood score at the end ($\rho=-0.68$, $p=0.032$) (Fig. 6).

IV. DISCUSSION

This study showed that a virtual agent's questions to evaluate automatic thoughts improved mood. Furthermore, the more questions that were helpful to the participant, the more the mood improved. Asking questions may provide new information to users. Because gathering information worked well, users improved their mood. We found that questioning to evaluating automatic thought was an important factor in improving participants' negative moods.

As with the cognitive reconstruction methods that humans have used, we have found that better questions are important in changing emotions. Therefore, our virtual agent suggested the effectiveness of the ability of guided modification of automatic thoughts. On the other hand, the survey in this study did not investigate the interaction between the questions given or the effect of timing. The questions' order may affect the helpfulness of each question, and further investigation such as randomization should be considered.

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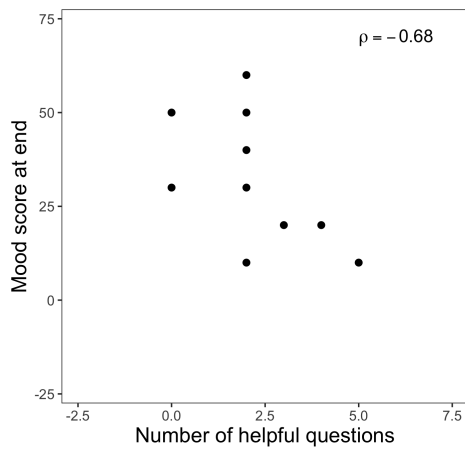


Fig. 6. Scatter plot between helpful questions Mood score at end.

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