

Generation of Multi-Party Dialogues among Embodied Conversational Agents to Promote Active Living and Healthy Diet for Subjects Suffering from Type 2 Diabetes

Kuthethur Sneha Jagannath Das^{1,2}, Tessa Beinema², Harm op den Akker² and Hermie Hermens¹

¹Biomedical Signals and Systems, University of Twente, 7522NB, Enschede, The Netherlands

²Telemedicine Group, Roessingh Research and Development, 7522 AH, Enschede, The Netherlands

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Abstract: Diabetes Mellitus is a chronic condition that is highly prevalent in the geriatric population. Self-management plays a key role in the management of this condition. Leading an active lifestyle and having a healthy meal are cornerstones in managing this condition. Now with the advancement in Information and Communication Technology (ICT), continuous and proactive care from the affected individual's side is possible. A change in the individual's behaviour would be beneficial in pursuing physical activity and adopting a healthy diet. This paper focuses on providing a dialogue based virtual health coaching through multiple Embodied Conversational Agents (ECAs), using strategies such as Motivational Interviewing (MI), Theories of Behaviour Change and Behaviour Change Techniques (BCTs). The dialogues are constructed to induce a behaviour change and promote motivation in the affected subjects to work on improving their physical activity and diet plan.

1 INTRODUCTION

With the advancement in medicine and technology, the life span of individuals has increased (Maresca et al., 2018). In many of the European Union countries, the ageing index has increased significantly. Statistics reveal that the average life expectancy would increase from 72 to 81 years (Silva et al., 2018). In such a situation, there is a need for explicit geriatric rehabilitation because the longer life span of the individual needs to be balanced with a good Quality of Life (QoL) as well (Maresca et al., 2018; Backman et al., 2018).

One of the new strategies that have been designed for geriatric care is telemedicine technology (Maresca et al., 2018). Telemedicine is based on ICT. The common forms of telemedicine include telemonitoring and teleconsultation. These forms of telemedicine have proven to be beneficial for the geriatric population (Maresca et al., 2018; Gokalp and Clarke., 2013).

One of the main challenges faced by the elderly population is the suffering of a chronic condition. Some of the commonly prevalent chronic conditions are diabetes, cardiovascular diseases and chronic

obstructive pulmonary disorder (COPD) (Silva et al., 2018). Using mobile health (m-health), for dealing with chronic conditions have proven to be beneficial (Silva et al., 2018). m-health has been useful in the aspects of personalizing the care provided, engaging the users and enabling them to manage their own condition. Some key features of m-health are nutrition management, planning of exercise, scheduling an appointment and, tracking of medicines (Silva et al., 2018; Karageorgos et al., 2018).

Diabetes Mellitus is a chronic condition related to the deficiency of insulin or resistance to insulin and high blood glucose levels (Inzucchi and Sherwin, 2011). Type 2 Diabetes Mellitus (T2DM), formerly known as adult-onset diabetes is characterized by the ineffective use of insulin (Inzucchi and Sherwin, 2011). People suffering from T2DM, are at risk of developing cardiovascular conditions, stroke, blindness, gangrene in the foot which could lead to foot amputation and kidney failure to name a few (Pardhan et al., 2018; Backholer et al., 2012). Physical activity (PA) and a healthy diet have proven to be beneficial in the management of T2DM (Inzucchi and Sherwin, 2011; Di Loreto et al., 2003).

The treatment of diabetes can be enhanced through self-management by the affected individual. This can be achieved through monitoring and education (Sina et al., 2018).

Health coaching provided to the affected individuals could aid in the self-management (Gupta et al., 2018). In this type of coaching, poor health habits are targeted and worked upon by setting adaptable and personalized goals, monitoring progress, providing encouraging feedback and suggestions for further improvement. Health coaching aims to bring about a behaviour change in the individual (Snaith et al., 2018). With the advancements in the digital healthcare, the health coaching can be provided virtually through the form of virtual coaches. These virtual coaches could be the ECAs. ECAs can be seen as a part of a system that conveys messages to humans through facial expressions, hand gestures and voice (Shaked, 2017).

In this paper, the focus lies on developing dialogues for a panel of ECAs and a human user, where the human user is suffering from T2DM. The dialogues aim to provide education and awareness about T2DM and, motivate the users to adopt PA and a healthy diet. The dialogues are constructed using the theories of behaviour change and behaviour change techniques (BCT).

2 BACKGROUND

In the management of diabetes, Web of Things (WoT) is being applied. Websites provide information, problem-solving aids, social support and awareness. Higher end versions in WoT enable tailored feedback, self-monitoring of the condition and self-care in terms of medication, exercise and diet (Al-Taee et al., 2013). These developments are being made by using the principle of behaviour change (Al-Taee et al., 2013). Studies reveal that people suffering from chronic conditions have to go through behaviour changes in order to cope with the condition (Aujoulat et al., 2007). WoT and ICT based systems are being developed that take into account the feedback provided to the affected individual. Reminders in the form of text messages to take medications on time, electronic diary entries for tracking the diet and exercise pursued, education and tips to manage the condition and goals set are sent to the users (Nieto-Chaupis et al., 2017; Fioravanti et al., 2011).

Digital technology has enabled the creation of context-aware technology. These technologies contribute to virtual coaching from the confines of a home setting (Albaina et al., 2009). Many virtual

coaching systems aid in the pursuit of PA. One such system is Flowie which has been developed using the strategies of goal setting, self-monitoring and intrinsic motivation to make the elderly people walk more (Albaina et al., 2009).

Virtual coaching using ECAs is being explored for the purpose of telehealth and behaviour change (Lisetti et al., 2011). MI is being used to create health behaviour change interventions. MI is a client-oriented counselling approach whose main goal is to resolve discrepancies between the current behaviour of the patients and their set goals (Lisetti et al., 2011).

Emp-ODVIHC has developed an ECA based virtual coaching system based on MI. It includes strategies such as feedback (Amini et al., 2013).

Most of the times ECAs have a human-like appearance with the ability to process natural language and non-verbal communication. ECAs are being tried to be integrated into a medical platform (Ravenet et al., 2018). The ECAs being anthropomorphic in nature has proven to be beneficial in inducing motivation based on self-efficacy, interest and attitude (Baylor, 2009). Adoption of ECAs have been explored in the health domain for children with autism and for adults with cognitive impairments (Tanaka et al., 2017; Wargnier et al., 2015).

Providing telemedicine-based services in terms of self-monitoring and education has proven to be beneficial in improving the individual's diet intake and PA (van Doorn-van Atten et al., 2018).

3 METHODS

The focus of this paper lies in creating dialogues among the panel of ECAs and a subject with the chronic condition of T2DM. The dialogues need to be able to motivate the subject to adopt healthy behaviour changes in terms of PA and diet since these are the cornerstones in the self-management of T2DM.

Since behaviour change is the key factor here, it was decided that the dialogues would be written based on the theories of behaviour change and BCTs. Hence a thorough literature review as shown in Figure 1, was implemented using keywords such as motivation, behaviour change, intrinsic motivation, goal setting in health care, virtual coaching, self-management of T2DM, avatar-based coaching, health coaching and PA monitoring to name a few.

At the end of the literature review, the theories of behaviour change that could be used in the dialogue creation and relevant BCTs were chosen. Along with

this, the types of exercise that could be performed and the components of a healthy diet that would be beneficial for people with T2DM were found out. Based on these points the dialogues were created.

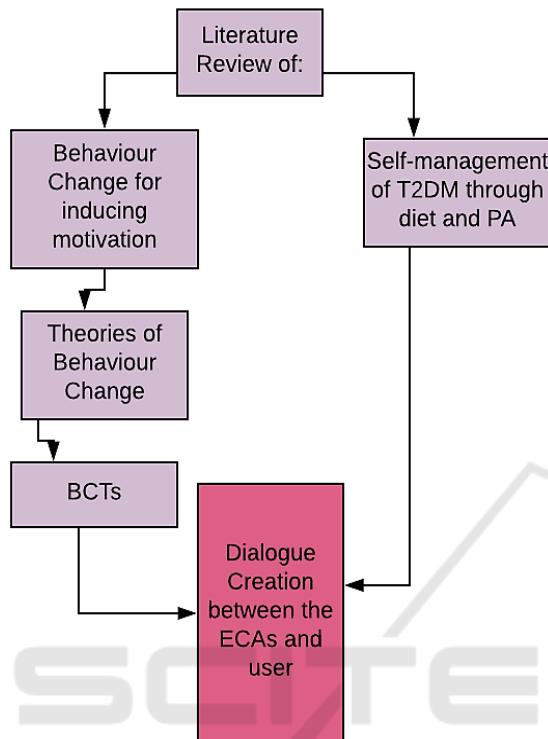


Figure 1: Method adopted in dialogue generation.

4 RESULTS

From the Methodology adopted, there are four main results obtained and they are discussed in this section.

4.1 Theories of Behaviour Change

At the end of the literature review of psychological theories related to behaviour change, the five theories discussed below were chosen to write the dialogues for the self-management of T2DM.

4.1.1 Goal Setting Theory

This theory focuses on the transition from the set goals to the actual performance. Two core factors are involved in this theory: difficulty and specificity of the set goals. Moderators on the effect of the goals are self-efficacy, feedback and commitment (Locke and Latham, 2002). Goals need to be realistically set and followed up. In T2DM management, we focus on the

pursuit of PA and a healthy diet. Hence, dialogues are needed that would focus on helping the user to set achievable goals that would have a positive effect on their T2DM control.

4.1.2 Social Cognitive Theory

This theory focuses on human behaviour that is motivated and regulated through self-regulation. According to the theory, self-regulation occurs through three sub-processes: self-monitoring, self-judgement and self-reaction (Bandura, 1991). The concept of self-efficacy is introduced through this theory. In keeping T2DM under control, self-management plays a crucial role. Monitoring the insulin and glucose levels and keeping track of the food intake and the levels of PA is needed for T2DM management. Hence, dialogues that focus on improving the user's self-regulation and self-efficacy are needed.

4.1.3 Protection Motivation Theory

This health psychology theory was developed as a framework to understand the impact of fear appeals on an individual. This theory is governed by two processes: 1. Threat appraisal 2. Coping appraisal. The cognitive predictors of this framework include severity, vulnerability, response efficacy which is based on the recommendations given and self-efficacy (Rogers, 1983). In the case of T2DM, through the threat appraisal and coping appraisal, a self-protection behaviour can be induced in the subject. For instance, if the user comes to know about, developing cardiovascular issues due to poor management of T2DM, out of fear and the need to protect himself from incurring the issue, he would be willing to let go of the sedentary lifestyle and quit eating junk food. The dialogues can be created based on this theory.

4.1.4 Information-Motivation Behavioural Skills Model

This model is developed based on three factors. They are the availability of information and knowledge in the particular health topic, motivation to change behaviour and the availability of behavioural skills to do the specific acts required to tackle the health condition (Fisher and Fisher, 1992). According to this model, information and motivation influence each other. In the case of T2DM, if the subject has the knowledge that he needs to adopt more PA to manage the condition, he would be motivated to take the stairs instead of an elevator. Similarly, if he is motivated to

manage T2DM, he would take the effort to gather information about the same. For instance, he would consult a nutritionist about a healthy diet plan.

4.1.5 Health Belief Model

This model tries to predict and explain when an individual would adopt actions pertaining to his health. According to this model, an individual would be ready to adopt healthy behaviours if he understands the susceptibility and severity of the health condition and would adopt the changes when the cues to action are provided (Janz and Becker, 1984). This model can be incorporated in the dialogues. For instance, if the subject is made to understand that eating too many sweets can worsen T2DM and hence the person is more likely to develop gangrene in the foot, he would understand that he is susceptible to it and the severity of the condition as well. Cues such as reminders by the virtual coaches that sweets shouldn't be eaten often can be provided.

4.2 Behaviour Change Techniques

Based on the theories selected in the previous section and taking into account that the subjects need to adopt a change in behaviour in terms of an active lifestyle and diet, from the latest BCT taxonomy, the relevant BCTs were chosen (Hankonen et al., 2014; Michie et al., 2013).

The BCTs chosen belong to the cluster of goals and planning, feedback and monitoring, social support, shaping knowledge, natural consequences, repetition and substitution and self-belief (Michie et al., 2013).

For instance, BCTs belonging to the cluster of goals and planning can be used in the improvement of PA. This could be in terms of achieving a required step count. The feedback and monitoring cluster would help the individual to follow up his set goals and his physiological parameters such as the glucose level. Similarly, through the BCT clusters of shaping knowledge and natural consequence, awareness would be created in the subject about T2DM management and keep the subject informed about the negative conditions that could occur if T2DM is not under control. BCTs of repetition and substitution cluster is useful in the formation of healthy habits such as cycling to the grocery store instead of using the car. These kinds of suggestions can be given via the virtual coaches through the dialogues. By using the BCTs from self-belief, the subject can be given the confidence that he could achieve the set goals. For instance, by reflecting on the subject's past success of

achieving good PA levels, the subject can be inspired to achieve higher levels of PA.

4.3 Physical Activity and Diet in T2DM

Literature review on the role of PA and diet in T2DM management revealed the type of exercises and components of a healthy diet that could be adopted by the subject. With regards to the PA, four groups of exercises were considered to be optimal for T2DM management. The groups are endurance, passive, resistance and aerobic types of exercise. These exercises can alter the body metabolism associated with T2DM by improving insulin sensitivity, blood glucose level and glycemic control. This is especially the case with resistance and aerobic type of exercises. Hence activities such as walking, running, swimming, cycling, rowing, skipping and exercises performed against resistance such as weight lifting are recommended for subjects with T2DM (Thent et al., 2013).

With regards to the diet, it was found that the diet adopted has an explicit effect on obesity and glucose level regulation. Hence it is highly imperative that a person with T2DM avoids food with excessive sugar content, oil and the intake of alcohol as well. Meals with low-calorie content are recommended for people with T2DM since it can prevent further progression of the condition because of insulin sensitivity improvement and reduction in weight. The ideal meal should have a balance between the contents of carbohydrates and high fibre (Lagerros and Rössner, 2013).

4.4 The Dialogues

The results of section 4.1, 4.2 and 4.3 are combined to generate the dialogues. The below dialogue set is a result of this combination. Three ECAs have been chosen for the virtual coaching panel. These coaches focus on motivating the user to adopt PA and a healthy diet. A brief persona description of the coaches and the user is discussed in the following paragraph (Le Rouge et al, 2013).

Bob: Exercise trainer (Male- 38 years)

Kim: Nutritionist (Female- 30 years)

Emma: Volunteer (Female- 57 years)

Dora: Subject (Female-55 years)

Six months ago, the subject Dora was diagnosed with T2DM and she is not happy with the way her condition is progressing. Hence, she has scheduled her first meeting to meet this virtual team of coaches. The coaches are Bob whose expertise lies in fitness

training through exercises, for elderly people since the last 10 years and Kim who has a Master's degree in nutrition sciences and specializes in coming up with a healthy diet plan for people with T2DM and cardiovascular conditions. In the panel, Emma a volunteer who has been suffering from T2DM but is successfully coping with it for the last 3 years is also present.

Bob and Kim are amiable kinds of personalities. Bob says his suggestions right away and is more authoritative whereas Kim likes to understand her subject and then give the required suggestions in a milder manner. Emma is a part of the panel since she feels that she would be able to relate to the subject's worries because she herself has gone through it in the past and by sharing her experiences she wants to boost the confidence of the subject. Dora has been recently diagnosed with T2DM and she is worried about her condition and wants to take the necessary steps to control it but she is confused about how to proceed with it. Hence, she has come to meet the coaches.

Below is a brief illustration of the dialogues that could take place between the panel and the user.

Dora: Hello. For the last 6 months, I have been suffering from Diabetes and with the medicines prescribed, I tried to take care of the condition. But I guess it is not working.

Bob: Hello! Don't worry. A lot of people who have come to us have been in the same state as you and are now doing much better. Isn't it so, Kim?

Kim: Yes. Of course Bob!

Emma: Yes Dora. Even, I faced a similar situation around 3 years back and with a good exercise and diet plan, I am able to manage the condition really well. (**BCT: Social Support(unspecified), Information about Health Consequences**)

Dora: Okay. This sounds promising. From where should I start?

Bob: Dora, to keep Diabetes under check, you need to follow both a good exercise plan and diet. Only then would your insulin and glucose levels be under control. (**BCT: Goal Setting(outcome), Goal Setting (Behaviour), Problem Solving, Information about Health Consequences**)

Emma: Bob is right. Could you tell us a little bit about your comfort with performing exercises?

Dora: I am not a very athletic person nor do I go to the gym. Once a while I go for walks but most of the time, I drive around.

Bob: Hmm. Okay. Maybe you could start with a 45minutes to 1-hour walk every morning. You can follow this time period for 10 days and then gradually

increase the duration by about half an hour or so. (**BCT- Action planning, Graded Tasks, Habit Formation, Instruction on how to perform a Behaviour, Goal Setting (Behaviour)**)

Emma: You need to focus on your PA levels. If it is not up to the mark, then you would land up in a problem. I have been through that phase! (**BCT: Information about Health Consequences, Information about Antecedents**)

Bob: Regarding your diet, the first step is to completely cut down on junk food. This means that you should cut down on sugary and oily foods. Work on this for the next three weeks starting from today. (**BCT: Goal setting (Behaviour), Habit Reversal**)

Kim: Yes. We can see how this goes.

Dora: okay. I am not very confident about this but I will try my best to stick to this plan.

Kim: I think you can do it! Find a friend who would be your teammate in this for a few days. (**BCT: Social Support (unspecified)**)

Emma: Yes! I think you will be fine as well. I would also suggest that you use a diary to write down about all this on a daily basis. It has helped me to stay motivated and get things back on track. (**BCT-Self-monitoring (behaviour), Self -monitoring (outcome), Information about Antecedents**)

Dora: Okay. Would you also suggest that I weigh my weight every week and check for the sugar level?

Kim: Yes. That's a good idea and it will help in getting a thorough feedback. (**BCT-Bio-feedback, focus on past success, self-monitoring, feedback from others, Information about Antecedents**)

Dora: Okay. See you!

Kim: Good luck!

Dialogues based on the BCTs such as Goal Setting(outcome) and Goal Setting (behaviour) follow from the Goal Setting Theory (Locke and Latham, 2002). Dialogues that use the BCTs belonging to the self-monitoring cluster are derived from the Social Cognitive theory which focuses on self-efficacy (Bandura, 1991). Overall, the information provided to the user in the dialogue is based on the Protection Motivation Theory, Information- Motivation Behavioural Skills Model and Health Belief Model. The dialogues provide information about how the PA should be pursued and the nature of diet and also focus on what could go wrong with the subject's health if the behaviour is not followed (Rogers, 1983; Fisher and Fisher, 1992; Janz and Becker, 1984). The coaching strategies incorporated through these dialogues are MI, Motivational Enhancement Therapy (ME) and diabetes specific coaching (Lisetti et al., 2011; Miller, 1995; Sherifali, 2017).

5 DISCUSSION

A dialogue set between a panel of ECAs and a subject with T2DM has been created for the purpose of virtual coaching. The dialogues are created using the psychological theories of behaviour change and BCTs. Predominantly in the dialogue set, the coaching strategies of MI and ME along with diabetes specific management is adopted.

MI and ME are useful in trying to induce an intrinsic motivation in the subject (Lisetti et al., 2011; Miller, 1995). Theories and BCTs on which the dialogues are constructed have been adopted in coaching systems related to the pursuit of PA and healthy diet (Hankonen et al., 2014). Goal Setting Theory, Social Cognitive Theory and Information Motivation Behavioural Skills model are used commonly in health psychology and are known for inducing intrinsic motivation (Van Doorn-van Atten et al., 2018; Locke and Latham, 2002; Fisher and Fisher, 1992; Miller, 1995). Goal setting is a very integral part of health coaching in order to induce a behaviour change (Snaith et al., 2018). The goals set need to be understood and agreed upon by the subject and through the dialogues, the concept of commitment in pursuing the set goal is being aimed for (Snaith et al., 2018).

The BCTs chosen focus on inducing an intrinsic motivation since this type of motivation would help the subject on a long-term basis (Seifert et al., 2012). This is the reason why the BCTs are chosen from the clusters mention in Section 4.2 and BCTs belonging to the cluster such as rewards have not been included (Michie et al., 2013). BCTs such as satiation or exposure is not used in this dialogue set because of the possibility that it would lead to poor management of T2DM. For instance, in satiation, the subject could be asked to eat a lot of chocolates in order to let go of the habit of eating sugary stuff but it might not go well with T2DM management (Michie et al., 2013). The BCTs focus on creating awareness about T2DM and its self-management. It tries to motivate the subject by giving her the confidence that she can do it.

In the coaching panel, three ECAs are present who have expertise in T2DM management. According to the literature, a positive effect in health coaching is possible through a multi-virtual coach system (Kantharaju et al., 2018; op den Akker et al., 2018). Persuasiveness from the coach's side also adds more value to the health coaching. Studies indicate that a coach with an authoritative personality can be more successful in inducing a behaviour change (Prochaska et al., 1994). Hence, Bob's character is shown to be authoritative. Cross-gender interaction has also been

recommended in this type of coaching (Kantharaju et al., 2018).

As a part of the future work, a user evaluation needs to be conducted to test the competency of the dialogues delivered by this multi-party ECAs. The persuasiveness of the dialogues and whether the users would be intrinsically motivated to adopt an active living and a healthy diet needs to be evaluated. Parameters such as how quickly the changes can be seen, that is whether and when they would move to the action phase in the five stages of change model needs to be looked into (Prochaska et al., 1994). For the virtual coaching to have maximal efficiency, the ECAs which comprise the heart of the coaching system need to be fully aware and updated with the overall health and behaviour of the subject (op den Akker et al., 2018). For instance, if Dora is attending the second session with the panel and if there is an improvement in PA, then the coach needs to be automatically able to say it during the session. This could be implemented for instance through a Heart Rate (HR) sensor worn by Dora, where the HR values are indicated in prior to the system of coaches. This way, the system can be tailored and adapted in specific to each user. Similarly, to improve the adaptability and smartness of the system, the coaches need to be able to predict the stage of change of the user, this could be done through a short questionnaire that could be filled by the user before the session starts and based on the questionnaire results, the ECAs can provide a tailored coaching to the user.

In conclusion, a dialogue set was created between a set of virtual coaches and a geriatric subject suffering from T2DM using the theories of behaviour change, BCTs and coaching strategies such as MI and ME in order to make the subject adopt better lifestyle changes in terms of PA and diet.

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