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Modeling Interaction in Automated E-Coaching

A Case from Insomnia Therapy

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***Abstract*—This paper presents the work in progress on the Sleepcare-project. The aim of the project is to enhance the understanding of personalized self-help therapy with the aid of existing (mobile) technology, in particular in the domain of insomnia. For that, an agent-based e-coaching system is being developed in which various persuasion strategies for sustainable behavior change are evaluated. The e-coach is considered as a cooperative partner that combines various interaction modalities (e.g., dialogue, buttons, sensors) and that supports the individual with various exercises for insomnia therapy. Central in the approach is to improve the individual's adherence to these exercises. In this paper, we focus on the basic interaction model of the e-coach and some of its requirements, such as transparency, mutual commitment and adaptation.**

Keywords-cooperative agent; interaction model; e-coaching; cognitive behavioral therapy; insomnia.

I. INTRODUCTION

Personal coaching covers a variety of areas: there are sport coaches, sleep coaches, time-management coaches, and even life coaches in psychology. Personal coaching is regarded as a systematic application of behavioral science to the enhancement of work performance and well-being for individuals that do not have clinically significant mental health issues or abnormal levels of stress [1].

With advancing research in the field of information technology (IT), early attempts are made to replace a human coach with an automated system. In particular, health coaching dialogue systems have been developed on the basis of research methods from persuasive technology and behavior medicine, ranging from the treatment of depression to sleep disorders [2][3][4][5]. Below, we will refer to these automated coaching activities as e-coaching. N.B. Strictly speaking, e-coaching also covers the inclusion of human therapists that communicate by means of IT.

Compared to traditional human-human coaching, (mobile) e-coaching offers important advantages: mobile IT permits the assessment of relevant momentary information and the delivery of fully automated feedback tailored to the individual and the current context; its infrastructure enables the obtainment of objective data from non-obtrusive sensory measurement and integration of these data into the treatment; and its communication platform facilitates information exchange between user groups, i.e., peers, human therapists, and medical institutions. The e-coach can be part of a stepped health-care structure where human care providers take over when problems are detected.

This paper presents the general interaction model of an agent-based e-coaching system for Cognitive Behavior Therapy (CBT). The model is applied in the context of the Sleepcare-project [6], where a mobile e-coach is being developed that mimics the role of a personal coach and that offers a tailored counseling program in the domain of insomnia. In the project, we carefully try to separate coaching and insomnia related knowledge, and aim at experimental validation of persuasive strategies that improve adherence to exercises. Before we discuss the details of the model (Sections III and IV), we first briefly focus on some relevant properties of CBT for Insomnia (CBT-I, Section II).

II. INSOMNIA THERAPY

Insomnia is a sleep disorder with a prevalence of about 10% in the general population [7]. People with insomnia have difficulty initiating and/or maintaining sleep which impairs daytime functioning [8]. Insomnia can have severe consequences (e.g., concentration problems, emotional instability, increased risk of accidents).

Today, it is widely accepted that non-pharmacological treatments, such as CBT-I, produce sustainable positive changes in the condition of insomnia [9]. CBT-I is designed to change dysfunctional beliefs, attitudes and behavior that support sleep-disruptive habits, thoughts and emotions, and offers a variety of exercise types that differ in aim and properties [10]. For instance, relaxation exercises aim at a relaxed body and mind; sleep restriction involves curtailing the time spent in bed to build up a sleep debt during the day; sleep hygiene aims at managing environmental factors and non-sleep related behavior that may be either detrimental or beneficial for sleep. In human-human therapy, the actual intervention is usually preceded by a one- or two-week baseline sleep diary monitoring period, but some exercises, such as relaxation, may be started right from the beginning.

In general, the therapy has a particular time frame, a variety of assignments that may be scheduled in a particular order (allowing overlap), and a periodic evaluation of the assignments. We will return to this in Section IV-C.

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One of the major problems in CBT is non-adherence to the therapy [11] and CBT-I is no exception to this. In CBT-I there may be various reasons for non-adherence. Exercises may be too strenuous: people may enthusiastically start the therapy and discover that sizing down the time spent in bed or getting out of bed in the middle of a cold and dark night requires a great deal of effort. In addition, people may have doubts that an exercise contributes to a solution of the problem. Research has been done on improving the treatment efficacy of self-help therapy by the inclusion of persuasive strategies to support adherence to therapy exercises [12][13]. For instance, it was demonstrated that adding feedback to an online treatment for insomnia enhanced both adherence and efficacy [14]. Mimicking the persuasive characteristics of human coaching could be an important factor in the improvement of adherence, but introducing these strategies requires careful analysis of the coaching process.

III. THE COACHING PROCESS

The coaching process can be considered as a series of conversations between two individuals – the coach and the coachee – for the benefit of the coachee in a way that relates to the coachee's learning process [15]. Crucial element is a relation of trust between coach and coachee. Often, therapy related activities are extrinsically motivated (by the coach telling the coachee what to do) and the coachee may not experience immediate intrinsic reward after performing an exercise. Within certain limits, the coach controls the life of the coachee. Therefore, a coach that suggests exercises that are too demanding or that do not manage the coachee's expectations with respect to the required effort or outcome, will likely cause mistrust, frustration and premature withdrawal from the therapy.

A coach should act as a cooperative partner who not only helps to set therapy related goals, but who also offers support to develop a personal treatment plan and uses persuasive strategies to improve adherence to the exercises. To apply this approach, the coaching process should have at least the following elements: a. the coach should be *transparent* about the source of, the importance of and rationale behind exercises; b. the coach and coachee should agree on the investments in the therapy in terms of closing a *contract* (c.f. [16]) and c. the intervention and support should be *adapted* to the individual coachee on the basis of the unique circumstances and characteristics of the coachee [13]. These three elements will form the basis of the interaction scheme presented in Fig. 3 that models the interaction between e-coach and coachee.

IV. BEHAVIOR MODEL OF THE E-COACH

Fig. 1 shows the interaction scheme between the coachee, who interacts through a (mobile) communication device, external sensor devices, a communication medium, such as the internet, and the e-coach system. Sensor devices may deliver, for instance, sleep related and environmental information, such as wake/sleep stage, and light and sound conditions.

The e-coach system consists of various interaction channels, an I/O-Manager that deals with technicalities of the in-

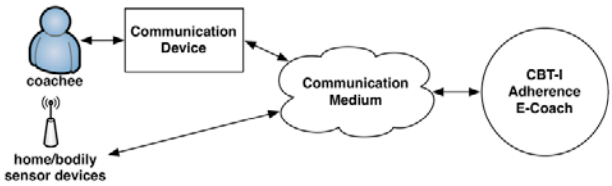

Figure 1. The basic interaction of a CBT-I adherence e-coach

and output, and a supportive agent that communicates with the coachee to initiate and support the coaching process in accordance with the therapy and communication standards.

A. Constraint based dialogue act generation

For the generation of supportive behavior by the e-coach, we propose a constraint-based approach [17]. The basic idea is that the coaching model of a well-formed coaching process needs to conform to a number of constraints. Whenever constraints are violated and detected, they have to be repaired by the e-coach by the generation of a dialogue act.

A constraint describes, for example, that the coachee should adhere to the details of a commitment: doing relaxation exercises twice a day. This constraint is violated when the coachee performs less relaxation exercises and the coach resolves the conflict with a dialogue act, e.g., by explaining the importance of the assignment.

Violations are not necessarily negative, however: if the coachee shows an outstanding performance and the coach did not generate a compliment, this is an undesirable state that has to be repaired. In this respect, the coaching process may be regarded as the maintenance of a balanced state [18]; as long as the coaching model is balanced, nothing happens.

The constraint approach is depicted in Fig. 2. The e-coach detects violations (*constraint checker*) and generates dialogue actions (*dialogue action generator*) on the basis of three types of information: background knowledge about timeless information (e.g., information about sleep disorders, persuasive strategies, constraints), the coaching process (history, plans, therapy schedule), and a repository that reflects information from the coachee's point of view (e.g., feelings, sleep quality, circumstances). Together, they form the *information base* of the coach. The generated dialogues are communicated to the coachee through the *I/O manager* using one of the communication channels. The I/O manager sends new information arising from the interaction with the coachee to the information base (via the *updater*).

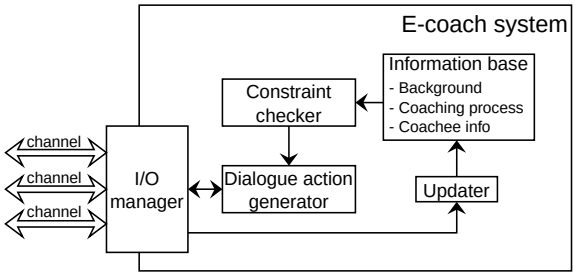

Figure 2. A constraint-based e-coach system.

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B. Conversational Behaviour

There are a number of dialogue actions between the coachee and the coach that update the information base (coaching process and repository) of the coach and change the state of the coachee. They can take place through various channels, most of them on a smartphone. Dialogue actions are the basic communicative actions that are the building blocks of more elaborate interaction recipes, such as introductions and evaluations of an exercise.

Both coach and coachee can take the initiative to start the interaction. The partners make working agreements as soon as possible and plan regular briefing sessions where they discuss, negotiate and plan the therapy and the coach process.

In one of the early introduction sessions, the coach introduces the *schedule*, which is essentially a shared agenda that corresponds with an object in the coaching model. All plans and agreements the coach and coachee make are stored into the schedule, where they can be viewed by both partners. In addition, both coach and coachee can initiate a conversation if one of them does not agree anymore with the specifics of a plan or agreement.

C. Interaction model of basic coaching process

The coaching process (introduced in Fig. 3) consists of three phases: an opening phase consisting of a two-way learning process between the coach and coachee, an intervention phase where the actual therapy is conducted and a closure phase during which the therapy can be ended.

The goal of the **opening phase** is twofold: improving transparency through a process of alignment and establishing commitment to the therapy in the form of an agreed contract. Depending on the extent of the process, alignment may refer to various types of information at three different levels [13]: the therapy level (time and effort investments, goals, insomnia-related knowledge), communication level (interface design, gender) and ethical level (privacy, trust, risks). Based on the information exchange, the coach may advise the coachee to withdraw from the therapy, for example on the basis of contra-indications in CBT-I, such as addiction and depression. In that case, the coach may refer the coachee to an experienced human therapist or a general practitioner (*inclusion/exclusion advice*). The coachee however, makes the final decision about whether to continue.

The **intervention phase** consists of different types of exercises, all aiming at support to reach the coachee's goal. The timing of each exercise is entered into the *schedule* in the introduction phase. The coach uses the schedule to initiate communication about a new exercise. Fig. 3 shows four exercises partially overlapping, as an example of a therapy plan.

The **closure phase** starts after all exercises have been performed or when the coachee desires to withdraw from the therapy. In this phase, the coach and coachee may evaluate the progress of the coachee, have a discussion about why the coachee ends the therapy, or make plans for relapse prevention. Discussing the (ending of the) therapy may give important information for future support strategies.

D. Exercise support

Although the exercises can be very different, they follow the same four steps (see Fig. 4). Every exercise starts with an introduction to the exercise (step A). During step B, the coach explains what is expected of the coachee and they can negotiate about the specifics of the exercise (e.g., frequency and timing of the assignments). When the coach and coachee agree, they establish a commitment by 'signing' a contract. The exercise properties are stored in the schedule, so that the coachee can view and adapt them and the coach can respond to constraint violations (e.g., by sending reminders to the coachee if the task is not executed on time). Step C consists of the coachee performing the exercise based on the schedule agreed upon in the plan & commit process. The final step D is a briefing session evaluating the performance at a scheduled time (committed to in the contract in step B). The coach may use adherence data and will ask the coachee about their

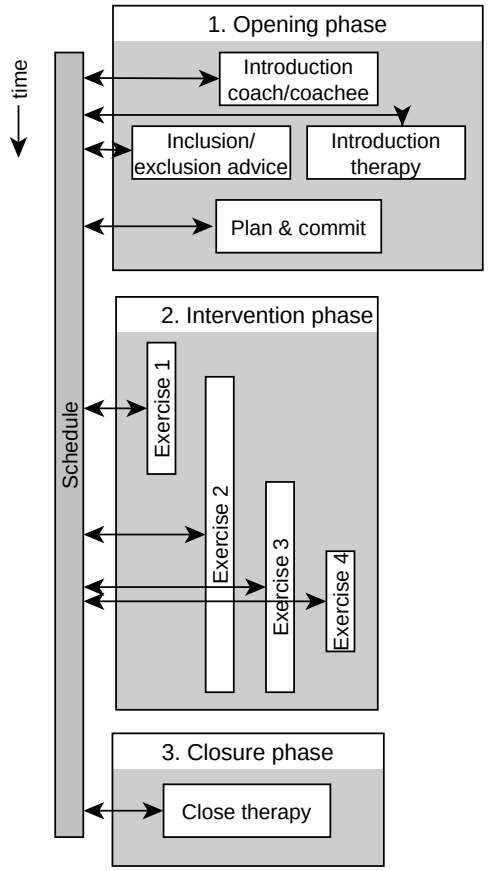

Figure 3. The interaction model of a basic coaching process.

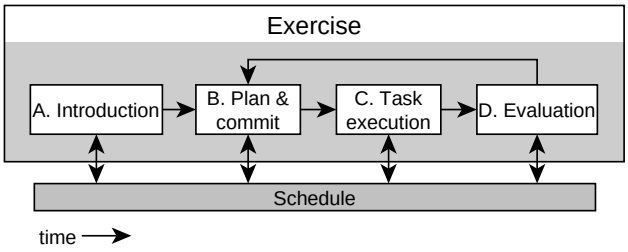

Figure 4. Interaction model of an exercise.

opinion. After evaluation, the exercise either ends, or continues with discussing the plan for the next cycle of the exercise.

V. DISCUSSION

This paper presents a generic constrained based interaction model applied in the domain of automated CBT-I. Since CBT-I is considered as an amalgam of a wide range of individual and communicative activities, it is to be expected that the model pertains to other mobile e-coaching domains as well. Therapy related exercises can be viewed as a particular type of activities that should be scheduled and adhered to by the coachee. Moreover, in all domains, e-coach and coachee should align, build mutual agreement about the investments, and evaluate and adapt exercises and communication to the individual characteristics of the coachee.

To improve exercise adherence, three elements were included that play a crucial role in the communicative behavior of the e-coach: *transparency*, *adaptation* and commitment to *contracts*. These elements can be found in various stages of the therapy. Transparency is implemented in the extensive introduction of the therapy and exercises at various levels; adaptation to personal circumstances or preferences is established in the introduction stage (plan and commit) and the various briefing sessions; the closing of various contracts is implemented in the introduction and intervention phases where the coachee can either commit to an agreed plan or withdraw from the treatment or exercise.

VI. CONCLUSION AND FUTURE WORK

The aim and strength of the Sleepcare project is the genericness of the approach, i.e., developing a system that can be applied to many coaching domains. In addition, developing a mobile phone app allows the coach to support the coachee at any time, not only during therapy hours. The generic nature together with the limitations of smartphone applications (limited resources, small screen, etc.) provide a challenge: the need for designing an efficient system with many functionalities and still compact enough to run on a mobile phone.

Currently in the Sleepcare project, a smartphone app is being developed and tested. The latest version contains a sleep diary tool, a relaxation exercise and is able to send reminders. Three reminder settings are currently being tested in an experiment: no reminders, self-scheduled reminders and opportunity detection reminders.

Future work consists of further development, implementation and empirical validation of the model in the domain of CBT-I. Important questions to be answered are how coaching strategies and sleep related knowledge can be separated to guarantee the generic nature of the coaching model and how the abstract interaction scheme can be transformed into user-friendly and natural interface characteristics.

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