Investigating the Automation of Self-Help Therapies by means of Visual Tooling

Universiteit Utrecht

AUTHOR
G.J. (Gerben) Kolkman
4118863

SUPERVISORS
Dr. ir. R.J. (Robbert Jan) Beun
Prof. dr. ir. J.F.M. (Judith) Masthoff

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Abstract

There are many self-help therapies around, some are written in the form of books while others are internet-based. These forms share similarities but they also have their differences. One of these differences is the transfer of information. Where books only convey information one-way, internet-based therapy allows for interactivity between therapist and client. An e-coach is an example of a mobile agent that coaches their clients (coachees) through a process of behaviour change. These e-coaches mostly focus on a single therapy domain and are developed specifically for that. However, the creation of these e-coaches requires extensive technical knowledge and programming skills. Throwing up a barrier for writers of self-help books to develop their own e-coach.

We propose a framework for an authoring tool (CoachLab), that allows authors of self-help treatments to develop e-coaches without technical knowledge. CoachLab is unique in its underlying generic framework that allows authors to generate conversation-based e-coaches for all therapy domains by only providing therapy specific variables. For this research we focused on the development and generation of conversations. These conversations were created by analysing existing self-help books and e-coaches.

Since CoachLab is based on conversations, it is important for authors to convey their message properly. Even though CoachLab enables authors to generate these conversations based on specified variables, authors should be able to adapt them to their own insights. This should again be possible without any programming knowledge. The built-in dialogue editor allows authors to adapt existing and create fully new conversations. To conclude, we created a generalising framework for creating conversation-based e-coaches based on existing therapies and processes, along with an editing tool that removes the technical threshold for authors designing those conversations.

Contents

1 Introduction

Self-help books fill the shelves in all bookstores these days. A particularly popular topic is stress, since there seem to be burnt out and stressed out people everywhere around us. But stress and emotional detachment are not something exclusive to our current age, even though we like to think so. The early Romans and Greeks already described these feelings [1]. They figured an excess of one of their four humours, black bile, lead to feeling lethargic and exhausted. Though scientific substantiation seems to remain absent, it is clear burnouts are not a 21st century exclusive. The increasing awareness of the importance of mental health among people however does help with improving the symptoms or even curing the disease. As a consequence more and more people are lead towards psychologists or therapists [2], or try to find their salvation in *self-help therapies*. Because of the high demand, the supply of *self-help therapies* is increasing. They are offered through a variety of media (e.g. books, online courses, electronic therapist), however most of these media lack interaction and other techniques to increase adherence.

Self-help therapy usually refers to coping with one's problems without the aid of others. However, in this paper the definition is slightly less strict and only excludes the aid of a **human** actor. Regular forms of these therapies such as acceptance and commitment therapy (ACT), and cognitive behavioural therapy (CBT) are usually carried out with the help of a therapist. However, several meta-analyses have shown the effectiveness of self-help behavioural therapy [3,4] as well. Others showed the effectiveness of psychological treatments that were computer-based [5, 6]. Not all computer-based treatments did fully exclude human intervention. However, in [7] it was found there was no significant impact difference between therapist-assisted or non-assisted self-help therapies.

Self-help therapies have only recently been conducted over the internet, making use of computers, tablets, and (smart)phones. These treatments were traditionally offered via printed instructions or books [8,9]. The printed form of psychological self-help has been massively commercialised [9]. The books, however, are usually overly complex and often leave the reader more puzzled than before they started reading. This makes sense since the nature of these self-help therapies is by no means arbitrary and has required a therapist to study the subject and practice their skills on patients for many years. In [9] it is claimed that many of these books are not so productive at all and were likely created just because of the high demand and therefore possible financial gain. Part of the reason these books are not effective is their lack of interaction and personalisation. Hofman has shown the usefulness of personalisation when compared to general approaches [10]. A book merely poses an idea and distributes advice to the best of its abilities. Other delivery methods exist, such as: audio, video, and telephone or internet consultation [11]. These methods either face the same problems as books (a lack of interaction and personalisation), or they still require the involvement of a human actor. A way to address these problems is by substituting the role of a therapist with an electronic counterpart, an *e-coach*.

In this paper we combine knowledge of several behavioural therapies and a

generalising analysis of self-help books into an authoring tool for the creation of electronic coaches. The tool aims to create a framework based upon a thorough analysis of self-help books and that is applicable across several domains. The main goal is to provide therapists with a tool set that (1) guides them in creating an interaction-based therapy based on existing behavioural therapies, and (2) alleviates the initial threshold by aligning with the technical abilities of the therapist.

Central to most definitions of coaching is that coaching is a goal-oriented activity to help people enhance aspects of both their personal and professional lives by fostering self-directed learning through collaborative goal setting, action planning and feedback [12]. All of these aspects can be realised by such an *e-coach*; *"a digital agent that supports automated self-help therapies by portraying the role of a coach"* [13]. E-coaches have proven to be successful among several kinds of behavioural therapies, from malevolent eating habits to insomnia to depression [14–16]. During the coaching process the client (from now on referred to as *coachee*) will learn through: (1) individual (subjective) experiences as well as through (2) social and collaborative practices. The second dimension is where e-coaches can make a difference since it enables interaction and collaboration by means of dialogue.

Electronic dialogue partners have been around since the 1960's with Weizenbaum's Eliza [17], a Rogerian psychotherapist. Since then many have been created, most of which are focused on either business use cases or simple chatting functions. Many names for these digital agents have been suggested: conversational agents, conversational interfaces, chatbots, bots, conversational experiences, chat agents. In this paper it will be referred to as a *conversational experience*. This term captures the essence of its purpose; providing the coachee with a learning *experience*, which will be achieved through *dialogue*. Drop-out rates among digital therapies are still higher than average though [18]. To decrease these rates one can make use of *persuasive strategies*, which are defined as a collection of actions to enhance the ability and/or motivation of a coachee with regards to the intended behaviour change [19]. The tool discussed in this paper is aimed to be utilised by authors of self-help books or behavioural therapists, who want to create conversational experiences (portrayed as e-coaches) that support users (coachees) in their self-help therapy by making use of persuasive strategies.

1.1 Research Approach

The main goal of this study is to develop an authoring tool that provides a framework for creating interaction-based self-help therapies for behaviour change. Creating an e-coach, who takes the role of a therapist, requires a lot of technical knowledge and skills. The creators of an e-coach do not necessarily have the same occupation. So, whether it is a therapist, a self-help book author or someone studying the effectiveness of e-coaches, in this paper we will refer to the creator of the e-coach as an **author**. In practice most therapists do not possess these skills nor the funds to acquire them. The authoring tool will pro-

vide authors with a framework that aligns with the abilities of the therapist and that takes care of the technical elements. As a result the authoring tool will remove the initial threshold by lowering the cost and reducing the time it takes to build such an e-coach. To develop an authoring tool that will provide all these benefits the following research question has been established:

RQ - *How can the creation of self-help therapies for behaviour change be semi-automated with the help of (visual) tooling?*

To answer the main research question five sub research questions have been drawn up, all addressing parts of the main research question.

SRQ1 - *What are the characteristics of self-help behavioural therapies and (how) are they generalisable across different treatments?*

To determine the characteristics of self-help therapies that offer treatment in the form of dialogue counselling an extensive literature study has been executed. To find relevant papers backwards and forwards snowballing has been applied. The study focuses mainly on cognitive behavioural therapy (CBT) and acceptance and commitment therapy (ACT). Besides those therapies the use of behavioural strategies are discussed together with a new model created to make an abstraction of the process of behaviour change. Several existing treatments and self-help books have also been analysed to extract characteristics of such a therapy.

SRQ2 - *Are there any existing methods/tools for the automation of self-help dialogue treatments, and if so, what functionality do they offer?*

If any existing methods or tools can be found these will be analysed and taken into consideration in the next research question; requirements for the design of the tool. The search for such methods and tools is conducted through scientific literature, but also via commercial products and applications. The overview this results in will help with determining requirements and possibly provide a framework to develop the authoring tool in.

SRQ3 - *What are the requirements for such an authoring tool from the viewpoint of the author?*

The elicitation of requirements for the design of the tool will be based on literature and a model created by Beun [20]. To get a proper understanding off all variables that exist in a self-help therapy several self-help books and exercises will be analysed. This will lead to the extraction of the variables needed to create an e-coach which will need to be implemented in the authoring tool.

If existing methods or tools are found in SRQ2 the strong suits and weak points are analysed to further build the requirements on. If comparable authoring tools already exist the applicable parts of their approach will be used as a foundation for the design.

SRQ4 - *How to design a tool adherent to these requirements?*

The development of such a tool will be based upon the requirements elicited in the previous research question. These requirements will only concern the usability and functional aspects of the authoring tool and will not have any influence on the technical decisions. These decisions will be based on available frameworks and libraries (as found in SRQ2) that will help to satisfy the requirements specified in SRQ3. The availability of documentation and the possibility of integration will also play a role in deciding on the technical issues. In the case of no suitable framework a prototype will be developed from scratch.

SRQ5 - *How good is such an authoring tool?*

The evaluation of the developed tool will take shape in the form of prototype testing. For the scope of this research the implementation and thus evaluation will be limited to the interactive editor for the creation of dialogues. The prototype testing will be focused on the functionality of the tool, with emphasise on usability. The user of the authoring tool in this case is the author and not the user of the final product (e.g. the digital therapy, the e-coach).

After these tests, the results will be analysed and any suggested improvements will be taken into consideration.

Research Methodology

The 5 sub-questions are based on, and can be related to, the engineering cycle from design science as formulated by Wieringa [21]. The engineering cycle, as seen in Figure 1, consists of four phases. This cycle serves as a guidance and helps to visualise the phases a design project has to go through. The research questions relate to the phases as follows:

1. **Problem Investigation:** (SRQ1 - SRQ2)

2. **Treatment Design:** (SRQ3)

3. **Treatment Validation:** (SRQ3 - SRQ4)

4. **Treatment Implementation:** (SRQ4)

   The fifth and final research question is the next iteration of phase 1 of the engineering cycle. It involves the evaluation of the implementation. Stakeholders will assess the usefulness and value of the tool and determine if it anything should be changed. If needed the cycle can be iterated over many times.

5. **Implementation Evaluation:** (SRQ5)

Treatment implementation

**Implementation evaluation /
Problem investigation**

- Stakeholders? Goals?
- Conceptual problem framework?
- Phenomena? Causes, mechanisms, reasons?
- Effects? Contribution to Goals?

Treatment validation

- Artifact X Context produces Effects?
- Trade-offs for different artifacts?
- Sensitivity for different contexts?
- Effects satisfy Requirements?

Treatment design

- Specify requirements!
- Requirements contribute to Goals?
- Available treatments?
- Design new ones!

Figure 1: The Engineering Cycle [21]

The sections in this thesis are roughly ordered according to the research questions. Section 2 starts discussing the current literature on behavioural therapies and conversational techniques, those form the basis of the e-coaching process which is discussed in Section 3. Section 4 follows with an abstraction of the coachings process based on literature. These questions answer SRQ1 and SRQ2.

The development of the framework start in Section 5 with a generalisation of self-help treatments (SRQ3). Our authoring tool CoachLab is introduced in Section 6 (SRQ4) after which CoachLab's dialogue editor is evaluated in Section 7 (SRQ5). We conclude with a conclusion in Section 8

1.2 Relevance

This study will provide value by contributing to both the scientific and practical domain. It adds value as it describes an abstraction of psychological and behavioural therapies and applies this to an automated way of creating interaction-based self-help therapies.

1.2.1 Scientific Relevance

This study focuses on something very practically relevant, as will be discussed in Section 1.2.2, the creation of conversational experience aiding in behavioural treatments. This reason combined with the novelty in the field of artificial conversation companions explains the lack of comparison material.

The framework provided by this study can act as a base for further research as well as a working tool able to create therapies and provide significant value in the areas of both; dialogue design and behavioural therapy. The framework contains new ways to structure dialogues and ways to optimise conversation flows within said dialogues. It provides knowledge in the area of conversational experience combined with self-help therapies that is generalisable across different health domains. This study also provides an overview of characteristics of self-help exercises and combines this with insight in variables used within self-help therapies as a whole.

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Furthermore the tool can be very useful in future research since researchers will be able to quickly generate an e-coach with slightly different characteristics to perform comparison tests. This will be particularly helpful to the fields of psychology and human computer interaction.

1.2.2   Practical Relevance

This authoring tool will reduce the costs and lower the threshold of setting up an e-coach by providing therapists with an accessible framework that is set up to take care of the basic needs for an interaction-based self-help therapy. Through visual tooling and a clear predefined process therapists can easily create new conversational experiences that simulate the behaviour of an e-coach. z

The choice of medium through which conversation takes place can have significant implications on the design of such a conversation. Behavioural therapy in the traditional sense entails one person speaking to another, or more specific: a client speaking to a therapist. Traditionally this all happened face to face. Therapists are expensive and only available to a limited extend [22]. Besides that, not all problems are considered urgent enough to go see a therapist for or people are hesitant to go because of the stigma around mental health [23]. Technological advances however, make it possible to create such a therapist out of nothing but electronic matter: an e-coach.

Another medium are the traditional self-help books. They are abundant with information but lack the engagement, interaction, and motivation enhancing techniques to help their readers adhere to the chosen therapy. Both of these problems can be solved by creating such an electronic coach. It costs clients way less then an actual therapist and it can utilise a range of persuasive techniques to increase adherence to the therapy. Creating such a coach is no easy task and requires intensive collaboration between the author and technical developers.

Both of these media have their advantages and disadvantages. The disadvantages of both ways can be mediated through the use of an e-coach. The cost and skills required to develop one are a threshold to many people though. Which is exactly what this authoring tool aims to solve.

2 Behavioural therapy & Conversation techniques

In this section two subjects will be discussed: i) two types of common behavioural therapy (the foundation of the self-help therapies we are analysing), ii) conversational techniques used in those therapies since dialogue will be the tool's main instrument. Starting off with an introduction to behavioural therapy and how those are used on a self-help basis in Sections 2.1 & 2.2. Two of the most prominent types of therapy will be discussed: i) cognitive behavioural therapy (CBT), ii) acceptance and commitment therapy (ACT). With the lack of adherence to self-help therapies as described in Section 1 the second part (Sections 2.3 & 2.4) will also discuss strategies to increase adherence to both therapy and e-coach.

2.1 Cognitive Behavioural Therapy

Cognitive Behavioural Therapy (CBT) can be described as an evidence-based approach to treat people with (mental) health issues [24]. It is a form of psychotherapy, and has been researched very thoroughly. Hundreds of clinical trials have been documented and added to scientific literature [25, 26]. It is a rather generic method applicable to a fleet of disorders; from depression to sexual offending, and from marital distress to bulimia [27]. The therapy is based on the linkage between our thoughts, feelings, and actions. It teaches patients to cope with unpleasant situations by facing them and identifying patterns when facing those issues.

These patterns are identified with the first step in CBT; cognitive therapy. This part of the therapy focuses on making the patient aware of the difference between the actual outcome of an event and their thoughts of the outcome of the event. So, the interpretation of such an event is causing the distress, not the event itself [28]. Once the patient is aware of this, they can start working on improving their behaviour towards these events. They do this by replacing their *automatic* negative thoughts with positive ones, regaining control over their emotions.

The other component of the therapy is behavioural therapy. This helps the patient identify problematic behaviour and change it accordingly. For insomnia therapy problematic behaviour might be too much stress, or too much blue light before bed time. Whereas improvement can be achieved by means of bedtime restriction or relaxation exercises [29, 30].

Concluding, CBT encourages patients to face their fears or problems and act different than they normally would. By facing those fears patients become aware of their self-limiting behaviour, while slowly being introduced to new coping strategies and breaking with malicious habits. [31].

2.2 Acceptance and Commitment Therapy

In 1982, Zettle and Hayes set up a framework as a new form of cognitive behavioural therapy [32]. In 1989 Hayes perfected the framework and named it

comprehensive distancing, though later this would be changed to Acceptance and Commitment Therapy (ACT), as it is now known [33, 34]. Whereas CBT, as described in Section 2.1, focuses on changing malicious behaviour, ACT yields a different approach. Within ACT the behaviour change is merely a result of the therapy, basically a by-product. ACT helps their clients to be aware of their surroundings and be present in their life. During the therapy clients are exposed to unpleasant feelings and learn to deal with them (e.g. to not overreact, and to not avoid). This effect leads towards more positive feelings, essentially guiding the client upwards in a positive spiral. ACT is based on six core principles, all of which should lead the client towards psychological flexibility [35].

- **Cognitive defusion**: Laying emphasis on the insignificance of memories, thoughts, and images. They are nothing more than words or pictures, even though they may seem like rules to be obeyed or judgemental truths.

- **Acceptance**: After being aware of the insignificance of these memories, thoughts, and images one must accept the coming and going of these experiences. It should no longer be a struggle to here a certain word or think of a specific experience.

- **Contact with the present moment**: The art of being mindful. Fully living in the here and now. Engaging in whatever it is you are doing, while being open, interested and receptive.

- **The observing self**: Transcending the sense of your own thoughts, a continuity of consciousness which is unchanging. Within this observing self thoughts can do no harm, emphasising you are not your thoughts, memories, etc.

- **Values**: Discovering the true purpose of your life, who/what do you want to be as a person.

- **Committed action**: Creating action plans to achieve goals that are set according to the values described in the previous principle. These actions are to be carried out responsibly, while always striving to lead a meaningful life.

By following this therapy and adhering to the six core principles people stop fearing certain thoughts or actions. By getting rid of this fear, which influenced or maybe even controlled their lives, people establish an improved behaviour in lifestyle. The key difference with CBT is the fact clients do not try to change the contents of their thoughts but learn to confront and accept them.

2.3   TransTheoretical Model

The TransTheoretical Model (TTM) was developed in the 1990's by Prochaska and DiClemente [36]. It was created to conceptualise the process of behaviour change, with health improvement as the focus area. At its heart lies the theory

of the Stages of Change (SOC) [37]. People move through different stages when committing to a change process. It varies for people in what stage of change they are and how long they find themselves in specific stages. The actions needed to transcend beyond the previous stage however, are not. Each stage also has its own set of principles increasing adherence by reducing resistance, facilitating progress and preventing relapses. By implementing these Stages of Change the TTM provides a method to appeal to people in all different stages instead of just the minority that is ready to change. The progressing between stages is by no means one-way traffic so clients can cycle between stages or traverse to earlier stages (e.g. having a relapse of alcohol abstinence and losing faith in a positive outcome). To finish the therapy the client has to progress through 5 stages; precontemplation, contemplation, preparation, action, and maintenance.

The **precontemplation** phase hosts people that are very resistant to change. Usually unaware of potential benefits of changing their behaviour or the destructive nature of their current behaviour. TTM was one of the first therapies to take this into account allowing to treat more people and utilise this as a way to make more people want to change.

The next stage is **contemplation**, where people know of the pros and cons of changing their behaviour, but are mostly more scared of the cons than excited about the pros. In this stage people should be aiming to take action within the next 6 months. People tend to be stuck in this phase relatively long, this is known as behavioural procrastination.

When people reach the third stage, **preparation**, they are ready for action and should be willing to do so within the next month. They have already taken steps towards their goals and created action plans, or are ready to do so. These are the people ready to take part in behaviour changing programs, and thus the most important group for this research as well.

The fourth stage is where the client takes (or has taken) **action**. Actions are mostly measurable and thus only certain criteria will satisfy the specific actions specified in the action plan. These criteria are either set up by the therapist or derived from standards within the professional healthcare domain.

The final stage is **maintenance**, in this stage clients do longer actively change their behaviour but rather try not to fall back into their old malevolent behaviour. People may find themselves in this stage for up to five years. In smoking for example the people relapsing after 1 year of abstinence is still around 50% [38].

2.4 Motivational Interviewing

Adherence to the therapy is something CBT or ACT do not put emphasis on. It is therefore important to enhance the adherence to the therapy by other means. One of those means is the style of conversation. Motivational Interviewing (MI) is such a conversation technique, and a systematic literature review by Rubak et al. shows its effectiveness [39]. The method of Motivational Interviewing was first created to help alcoholics get rid of their addiction [40]. Miller & Rollnick then generalised the method, and describe it as follows;

> *"Motivational interviewing is a directive, client-centred counselling style for eliciting behaviour change by helping clients to explore and resolve ambivalence." [41]*

Miller and Rollnick describe four phases in their method; 'engaging', 'focusing', 'evoking', and 'planning' [42].

The first phase, **engaging**, helps to establish a meaningful connection between coach and coachee. A first impression is very important to establish trust and affection [43]. Many factors can facilitate (or undermine) the building of such a connection. General things like; the emotional state of the coachee and their environmental surroundings. Though in this case it is specifically important to remember it is not a real person the coachee interacts with, this should be clear at all times and might affect the choices for certain dialogue flows.

Focusing is the second phase and enables the coach and coachee to determine which direction this conversation is going. The practitioner tries to distill the underlying problems and clarify what changes are hoped to arise from the therapy.

Having determined change goal(s) and having engaged the client into the therapy the third phase, **evoking**, begins. Its aim is to elicit the existing, and non-existing motivations of the client. With a focus on a specific change goal the client's own ideas and motivations are taken into consideration to achieve the goal. It is clear MI does not consult an expert-didactic approach; the client himself has to figure out their motivation instead of getting a prescription on how to change. People are more reluctant to change when they are told to by someone else. It is more productive to have a person voice their own arguments for change, increasing their adherence to the therapy [42]. When a client is already extremely motivated the evoking phase can be skipped or be rushed without too much emphasis on it.

The final phase is **planning**. This phase occurs when a person is motivated enough to start thinking about the how and when of the therapy. It is important to develop commitment by establishing a contract on which both parties agree. This contract serves as an insurance, reminding the client of his responsibilities and commitments. This contract is not set in stone however, it might need to be revisited or adapted along the course of the therapy. The goals in this plan of action can be analysed and/or prioritised via, for example, the S.M.A.R.T framework [44]. Miller and Rollnick did also find that often one iteration of evoking and planning is enough for clients to proceed making a change on their own. From which can be concluded the biggest bottleneck was the decision to make a change and therefore finding out *why* they wanted to make a change [42].

To conclude, MI mainly focuses on creating awareness among clients as to why they want to change. Instead of vague suspicions of why they want or have to change, clients should elicit the underlying reason(s) and preferably act out their own solution as well. After that a plan of action is set up committing the client to the program.

3 E-coaching

Grant described coaching as a result-oriented, systematic process where the coach facilitates life enhancing experiences and goal-attainment in the lives of non-clinical clients [45]. Coaching applies a more collaborative approach to learning than, for instance, regular therapy or teaching does. It respects the autonomy of the coachee and focuses on collaborative dialogue through which coach and coachee align their ideas, set goals, and constantly reflect on the results of current exercises [12]. This collaborative approach is important due to the very different circumstances people live in today's society. Context, character, and environment differ from person to person, which inherently leads to a generalisation problem; a solution for one might not be a solution for another. Personalisation and contextualisation of the coaching process is therefore critical to help coachees learn on their own instead of just being taught [46]. A generic model of such a process can be seen in Figure 2. Where the coach helps setting the goals, developing an action plan, and evaluating progress [47]. During the continuous cycle of taking action, monitoring, evaluating, and adapting the coachee always maintains his autonomy and is leading during the conversations.
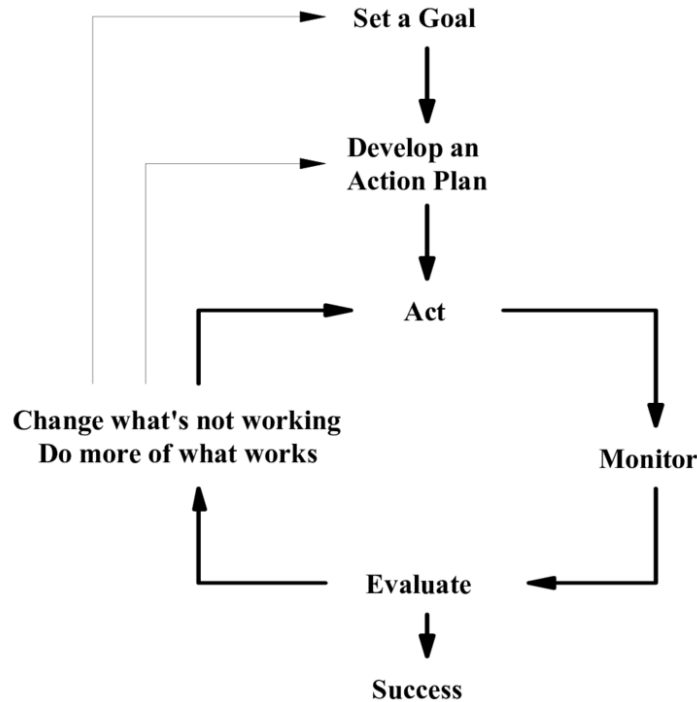
Figure 2: Generic model of a behaviour changing process [47]

With the focus of the coachings process merely on assisting instead of leading, this role lends itself perfectly for an automated system. Such an automated system will be referred to as an e-coach system. Such an e-coach system is without human interference and aimed at behavioural change in the health domain. It can be build based on different approaches or therapies, two of which are described in the sections 2.1 & 2.2. Where most studies focus on one behavioural issue, with the notable exception of [20, 48–51], this research will try to create a more generic model applicable to different health domains focused on changing behaviour. It will build on the constrained based interaction model by Beun et al. [20], using a conversational agent as means of an interface. To understand the design principles and choices, an explanation of the underlying therapies is necessary. Where the two therapies at the heart of this authoring have been discussed in Section 2.1 & 2.2, and the two important dialogue techniques that are applied by therapists are discussed in Section 2.3 & 2.4.

Another important aspect is the adherence to the coaching process. Low adherence rates are a complex and ever present problem in behavioural therapy [52]. As shown in a study on insomnia treatment almost half the people did not finish the treatment, with an exercise adherence as low as 52% [53]. Personalised therapies and shared-decision making are examples of interactive elements that increase the adherence of a coachee [13]. To make an effective e-coach, these interactions should be simulated based of off real therapeutic consults. When designing these dialogues it is therefore helpful to make use of *persuasive strategies*. Strategies aimed to increase motivation and ability of the coachee, increasing adherence to the therapy. Examples of those can be found in [53,54], and a more extensive guide created by Michie based on clustering, describes 93 techniques used in behaviour changing therapies [55]. Focusing more on the application of e-health, Beun et al. describe five persuasive techniques to strengthen social elements of an e-coach [13]. These techniques for behaviour change enable authors to positively influence the chance of a coachee's success.

3.1 Conversational Experiences

According to the Oxford Diary [56] a chatbot is a computer program designed to converse with a human being, especially over the internet. In our case just conversing does not fully cover it. The computer program will play the role of a coach and guide the human (the coachee) through the process of behaviour change. In this paper we will therefore refer to it as a conversational experience. Since the coachee experiences (or is at least supposed to experience) a self-inflicted behaviour change by means of conversational interaction with an e-coach.

Even though the term chatbot did not yet exist, in 1966 Joseph Weizenbaum created a Rogerian Psychotherapist called Eliza [17]. It did hardly anything more than rephrase the user's input in the form of a question, keeping the conversation going. So Eliza wasn't introduced as a chatbot though her functions do qualify as those of a modern day chatbot [57].

The Artificial Linguistic Internet Computer Entity, or ALICE for short, was

the next big step in the chatbot domain [58]. It was created in 1995 by Richard Wallace and won the Loebner prize three times (2000, 2001, 2004). This is an award issued each year for the most human-like chatbot. The results are based on their performance on the Turing test. Where Eliza made use of very simple pattern matching, ALICE took it a step further and made use of the Artificial Intelligence Markup Language (AIML) [58]. The current industry standard for human-like chatbots, Mitsuku, is based off upon AIML. Figure 3 shows how Mitsuku compares two words using the AIML language.

```
<category>
<pattern>BOTCOMPARISON</pattern>
<template>
    <learn>
        <category>
            <pattern>
                <eval><uppercase>BOTCHECK <get name="comparevalue1"/></uppercase></eval>
            </pattern>
            <template>
                <think>
                    <set name="match">YES</set>
                </think>
            </template>
        </category>
    </learn>
    <srai>botcheck <get name="comparevalue2"/></srai>
    <srai>botremovecomparison</srai>
</template>
</category>
```

Figure 3: AIML comparison of two words

A different approach to chatbots is taken by Cleverbot. It generates responses based on previous responses, so every time a question is asked Cleverbot learns. Since it went online it has generated more than 5 billion interactions, all of which are stored in a database.

All these examples cover chatbots who use text as input, however the last 5 years lots of voice-controlled chatbots have arose. Well known examples are Apple's Siri, or Google's Home/Assistant. Where some years ago text to speech synthesis was still a struggle, currently it is relatively simple to implement. It is even possible to differentiate between different voices by measuring their wavelength signatures [59].

In most cases chatbots are digital users of/within popular messaging apps such as Facebook Messenger, Slack, Kik, and others. They are powered by software created based on artificial intelligence premises. The chatbot is often mistaken to be the service itself, however it is merely an interface for the service that is behind it [60].

3.1.1 Adoption

To determine the acceptance of conversational experiences by clients, other studies have looked at adoption rates. Shevat defines four stages of adoption for chatbots, as shown in Figure 4 [60]. At the time the book was written (early 2017) Shevat reckons we are still in the first phase, though moving towards the second one. Currently it is fair to say we moved on to the second phase with companies like Facebook and Google acquiring bot development frameworks
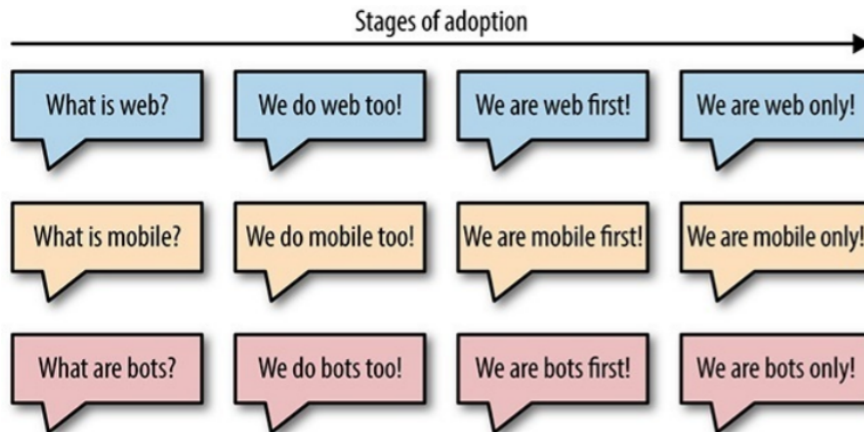
Figure 4: Stages of Adoption

and big companies like KLM-Air France, Rabobank and Domnino's making use of chatbots [61]. And even though chatbots have come a long way, they still need to improve. For example, when setting up two bots to talk to each other they will not have a conversation like normal humans would. An example is Cleverbot, which seems to get stuck in a funny loop referred to as the "Canada loop" where the two bots keep giving each other compliments (referencing to the apparent polite nature of Canadians). So, before companies will incorporate a bot-first mentality, chatbots will likely have to make the next big step in NLU enabling chatbots to accomplish more complex tasks. Too high a degree of human imitating behaviour however, can evoke an unpleasant experience for the user of the chatbot. Giving them a feeling of discomfort and of being deceived [62]. This may be due to the fact the technology is still new which makes people wary, they want to know the limitations of the chatbot [63]. It is also important to note that conversational interfaces will not be a direct substitute for all mobile interfaces. In the same way mobile interfaces are not necessarily good replacements for every application of a web interface (for example applications with a lot of text, or large tables quickly become confusing on a small mobile screen) [60]. For our purpose a conversational interface has been proven to be effective [14–16], however it remains important to keep the limitations in mind.

3.1.2 Designing a Conversational Experience

When designing a conversational experience it is critical to start of with a framework [60, 64]. Martin mentions 4 criteria to define the structure of a chatbot; scope, persona, functional priorities, and flow(s) [64]. These criteria recur in the description by Shevat [60]. He suggests to first define a use case (which includes the scope, role, and functional priorities) and after that to start scripting the

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conversations, distinguishing between main- and sub-flows, and error handling. Afterwards the mock-up/prototype conversation should be tested, preferably on possible end-users.

The defining of the use case is arguably the most important step. Considering the technical imperfections and overall novelty of the field, conversational experiences should be created with a clear goal in mind. Ensuring that whatever it is supposed to do, it does well. Specifying this helps to filter out unnecessary complicated elements that do not contribute to the main objective of the chatbot. When developing a chatbot that provides information about mortgages, the average price of houses in the user's area might not be relevant. Setting a clear scope helps to reason more clearly about such design decisions.

The defining of the role is another vital step in designing a conversational experience. The role a bot takes on depends on context and what audience it is facing. It makes sense with humans as well: a funeral director will probably be out of a job if he comes across as some jolly lunatic, while a dead-serious clown doctor does not make much sense either. In the domain of electronic health a credible but approachable person would be favourable. The bot needs to instill a feeling of authority but at the same time a welcoming and open attitude to make the user feel at ease. Trust and a meaningful relationship are very important to establish between coach and coachee [43].

Even though the role is predetermined, the personality does not have to be fixed. Especially when considering the health domain some people might need a little more confirmation and endorsement while others need to be pressed to get moving. With upcoming techniques like sentiment analysis this seems possible in the near future.

When the scope and role of the bot has been identified, the conversational flows (e.g. the tracks within a conversation that the bot is able to follow) should be designed. The scripting of the (main-) flows provides insight in possible deadlocks and forces the designer to think about desired behaviour. Besides desired behaviour, users will try to trick or break the system and this should be handled as well. By creating the flows it will be more apparent where errors or flaws might appear in the system.

All these steps are important for our authoring tool since we are trying to guide authors in creating an e-coach. So besides the therapeutic aspects and adherence improving strategies the manner in which to design a conversational experience will be guided as much as possible during the creation of the e-coach.

3.2 Coaching Process

The general process of a self-help treatment for behaviour change is similar in most studies [20, 47, 48, 65]. It follows a basic structure as shown in Figure 2. This paper will build further on the model by Beun et al. since it is the most sophisticated and was developed for a similar purpose (the creation of a dialogue-based e-coach) [20]. As shown in Figure 5, it consists of three phases: i) opening, ii) intervention, and iii) closure. Since we are generalising and our tool cannot

cover every aspect we assume each coaching process has a closure phase, meaning it will not go on forever.
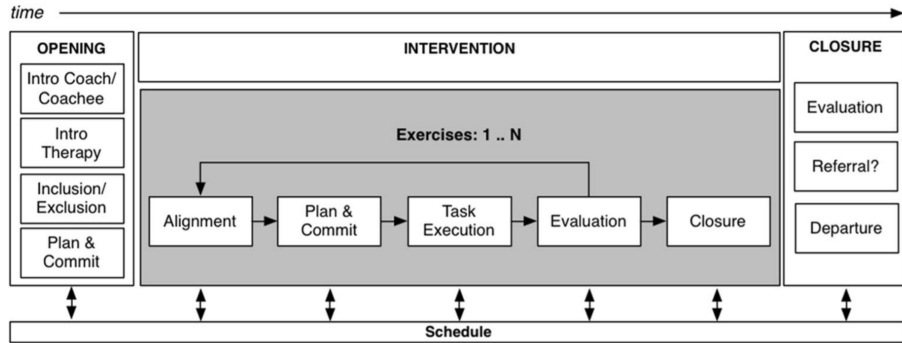
Figure 5: Behaviour changing process by Beun et al. [20]

In the **opening phase** the focus is on establishing a relationship between coach and coachee and setting a goal. Also to improve transparency through the process of alignment and establishing commitments. These commitments are usually in the form of some mutual agreement by signing some "contract". Alignment is the process of aligning information between e-coach and coachee which may happen at three different levels [11]:

- The *therapy level* conveys information needed for a fitting individualised therapy. The information about the coachee can include, but is not limited to: the coachee's state of change, age, expectations and investments, time schedules, mutual commitments, therapy starting point, and therapy-related knowledge.

- The second level, *communication*, refers to the interaction between the coach and coachee. Examples are interface design, formality, politeness, personal reference, gender, modality preference, and language use.

- The *ethical level*, that is, information that refers to the interests of the coach and coachee to establish a relation of trust. Examples are privacy and safety-related matters, the involvement of other parties, the system's credibility, commercial interests, and risks of the therapy.

The **intervention phase** is constructed by means of the exercises a coachee has to perform. These exercises are meant to help and support the coachee in their behaviour changing process. To plan the exercises the e-coach should have a *Scheduler*, this scheduler is maintained by the system but should sometimes be editable by users (coachees). An example is changing the execution time of the exercise, this might happen if the time chosen before accidentally interferes with the "real-life" schedule of the coachee.

Another exception is the order in which exercises are to be executed. If there is a specific order the therapist should be able to specify prerequisites of finishing a previous exercise. The scheduler should in turn take this into consideration and only plan the next exercise if the prerequisites are satisfied.

As shown in Figure 5, the structure of an exercise is also broken down into several activities: i) introduction, ii) plan & commit, iii) task execution, iv) evaluation, and v) closure. Activity i introduces the exercise to the coachee and explains what is expected, following in ii is the planning and committing. Negotiation about the specifics of the exercise is a powerful tool to increase the feeling of autonomy and may increase intrinsic motivation of the coachee [66]. After agreeing on the commitment, the coachee executes the task after which an evaluation follows. This evaluation is usually done weekly and it might lead to adapting the action plan to the new situation. If the exercise is executed to the satisfaction of the coach the exercise moves to the final activity closure, which consists of an overview of the exercise and possibly additional information or a preparation for the next exercise.

The **final phase** is the closure phase. It evaluates the whole therapy with the coachee and may include tips on preventing relapses and on maintaining a healthy life in general. Some therapies might refer the coachee to a specialist if further attention is required.

3.3 Existing Tools & Frameworks

As described, several studies all show the same bare structure of a behaviour change process. The model by Beun et al. [20], as shown in Figure 5, will serve as the baseline for the characterisation of behavioural therapies. The three phases (opening, intervention, and closure) are used to split the characteristics up into groups.

Even though the global structure of the behaviour changing process is clear no *autonomous* authoring tools exist. Bickmore et. al. have tried to create a reusable framework by creating an ontology, this however is too complex for regular therapists to work with [48], and ultimately even for them, since the project seems to be dropped.

Another example is an architecture developed by Allen et. al. to create more realistic conversational systems [67]. This architecture stems from 2001 and has since then been slightly adapted, though the focus shifted more and more towards natural language processing (NLP). Both of these authors attempted to create something covering all health related topics, which resulted in comprehensive ontologies that provide great insight in the high-level structure of health treatments and into the complexity of the nature of our speech. However, neither of these frameworks are usable by people who don't know the framework. It requires extensive studying to make sense of it, and does not just take knowledge of computers but of natural language processing as well. Due to their complexity and their focus on NLP these ontologies are relatively inaccessible.

Another framework in literature is a conceptual frameworks by Ochoa et.

al. [68], the LAES framework. In his paper, Ochoa proposes a loosely coupled conceptual architecture that would aid in designing an e-coaching application. The framework decouples the e-coaching system structure from the actual behaviour, allowing for incremental design of these e-coaches. However, this framework is by no means autonomous and still requires implementation by software architects/programmers.

A project that somewhat resembles ours is the creation of Lifeguide. Lifeguide is an example of an authoring tool for behaviour change, it however still requires the help of humans to construct a therapy [69].

So, a single model/tool for the creation of e-coaches treating different kinds of disorders does not exist. There are, however, a multitude of chatbots that were created for a single therapy. In Table 1 we present a (non-exhaustive) overview of the type of disorders that were tried to be treated with the help of a chatbot.

Disorder	Reference
Insomnia	Beun et. al. [20]
Alcoholism	Lisetti et. al. [70], Elmasri & Maeder [71]
Stress	Cameron et. al. [72]
Dementia	Atay et. al. [73], Cruz & Favela [74]
Obesity	Fernadez et. al. [75], Kowatsch et. al. [76]
Diabetes	Cheng et. al. [77]
Depression	Roniotis & Tsiknakis [78]

Table 1: Papers on e-coaches for treatment of a single disorder

Outside of scientific literature there is a lot of commercial tooling on the market as well. The downside is the popular tools are very business-oriented and the less popular tools usually have very poor documentation.

Our initial idea was to implement natural language features (by means of a chatbot framework) into the final dialogue-based therapy that will be created. However, this proved to be too difficult since the frameworks either did not support visual programming (required for authors) or did not support the required technical aspects such as external triggers, or a publicly available API. An overview of analysed chatbot frameworks is shown in Figure 6. It shows 6 columns:

1. **Flow-logic**: Depicts the logic that was used by the framework. Whether it uses a flowchart (i.e. a dialogue-tree) or it uses an intent-based approach[1]. These determine how the conversations are structured, and how to model the flow of a conversation.

2. **External trigger support**: Whether or not the framework support external trigger, such as messages from other tools.

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[1]This is a common distinction within the realm of chatbots. See `https://chatbotsmagazine.com/bot-talks-intent-based-vs-flow-base-conversations-798788dc9cf6`

3. **Development style**: Three types of development styles were distinguished: i) programming-only, ii) visual development only, and iii) a combination of both.

4. **Public API**: Whether or not the project has a publicly available API, to communicate with.

5. **Open source**: Whether or not the project is open-source, so the code is adaptable.

6. **Free version**: Whether or not the framework has a free version to create the chatbot. This might still imply a pay-wall for the actual release of the chatbot for customers.

Chatbots

Name	Flow-Logic		External trigger support	Development Style			Public API	Open Source	Free Version
	Intent-based	Flowchart-based		Programming	Visual	In between			
Dialogflow	✓	X	✓	✓	X	✓	✓	X	✓
Chatfuel	✓	✓	✓	✓	X	✓	✓	X	✓
ManyChat	X	✓	✓	✓	✓	✓	✓	X	✓
Flow XO	X	✓	✓	X	✓	X	X	X	✓
Botkit	X	✓	X	✓	✓	✓	✓	✓	✓
Wit.AI	✓	X	✓	✓	X	X	✓	✓	✓
Sequel	X	✓	✓	X	✓	X	✓	X	✓

Figure 6: A comparison between chatbot frameworks

NLP is still very much under development and will likely become more accessible in the future. By splitting up the therapy into separate dialogues, the addition of NLP is made more accessible since it can be used only in particular parts of the therapy and there is no need to replace/change the rest of the structure.

Since NLP is no longer within the scope and there are no specific existing tools or frameworks that are useful to us, the decision fell to start building our own tool. In Section 6 we will discuss a part of the architecture of the tool and its components, followed by a motivation for our choices regarding implementation, such as programming languages and frameworks.

4 An Abstracted Behaviour Change Model

In the previous sections the main therapies and methods revolving around behaviour change have been described. They all have some commonalities which will be described in this section in order to form a new high level, abstracted model of behaviour change utilised to create the authoring tool. First we give a short summary of the therapies and conversation techniques described above.

- **CBT**: Cognitive behavioural therapy consists of two parts; cognitive and behavioural. The cognitive part lets patients face unpleasant situations. Negative feelings associated with those situations are usually worse than the actual feelings when such an event occurs. These *automatic* negative thoughts are tried to be replaced with positive ones. Within the behavourial part malevolent behaviour is identified and changed accordingly, through exercises and action plans.

- **ACT**: Acceptance and commitment therapy focuses mostly on enabling the patient to make changes. It is based on 6 core principles, 5 of which help the patient become of aware of the harmful nature of their behaviour and determining why and how it would be beneficial to change this behaviour. The final principle is creating an action plan to achieve this.

- **TTM**: The transtheoretical model is based on the stages of change framework. Where in the first 3 stages awareness and motivations are addressed. Leading to the final 2 stages of action and maintenance where the patient acts out the plan created in the third phase.

- **MI**: Motivational interviewing is a useful method to make patients aware of why their behaviour is malevolent. It helps to elicit underlying motivations of the patient using a client-centred approach, in which a plan of action is drafted at the end.

The model we will be introducing is an abstraction of the behaviour change process. A similar model has been created by Mohr et. al. in their paper on the BIT model. The model is shown in Figure 7, and shows the user's state as a directed graph.
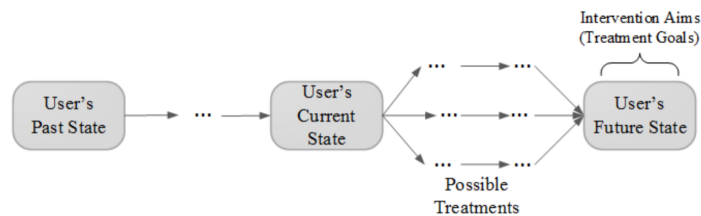
Figure 7: Model depicting the user's state by Mohr et. al. [79]

The transitions within the model are referred to as a set of interventions (treatments) to guide a client to a future state. This future state is a desired state which means, in case of a behaviour changing process, the desired behaviour. This aim or goal may include sub-aims which support the attainment of the larger aim. An example of the final aim might be weight reduction, with sub-goals: decrease caloric intake and increase physical activity.

We would like to propose an adapted version of this model (see Figure 8. First, by decreasing the amount of states to two: i) the current/undesired state (W_0), and ii) the desired state (W_1). We name the states 'worlds' to emphasise the influence of external factors on the user's progress.

The second addition to Mohr's model is the including of negative transitions. Mohr defined several behaviour change strategies but does not show the possibility of clients regressing or relapsing. His model focuses mainly on specific interventions/treatments changing the state of the user. There are however, other factors affecting the state of the user, like environmental factors (e.g. situation at home, arguments with family, losses, etc..). We therefore introduce two types of transitions: i) positive influences (enablers), and ii) negative influences (disablers). Transitions are possible between the different worlds or to themselves.

W_0 = Current/Undesired World
W_1 = Desired World
A, B = Positive influences (enablers)
C, D = Negative influences (disablers)
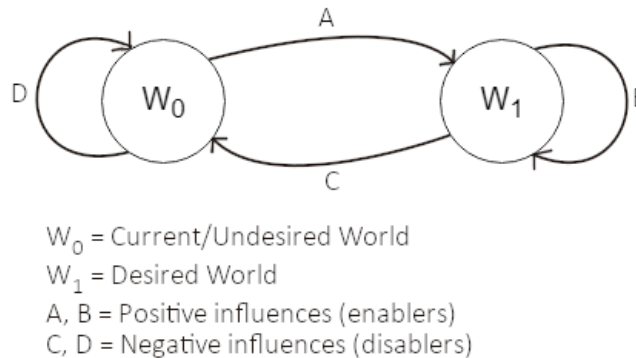
Figure 8:

Worlds We assume that the coachee starts off in a complex multidimensional space, the current state (W_0), and aims to achieve another complex space, the desired state (W_1). When starting the therapy the coachee is within one of the first three phases of the transtheoretical model (e.g. not yet fully started with their behaviour change process). In the case of an e-coach the coachee usually is in a state of discontent and wants to change. If he was still denying his problems, he would not have started the e-coach.

The desired state, W_1, as in Mohr's model, does not have to be a final state. During the planning phase (or because of the nature of the therapy) there might be some intermediary goals set to achieve the final goal. Some of these (intermediary) goals are expressible in concrete values like hours slept,

or miles ran. However, some might be more based on feeling (in depression treatment for example). This will differ between therapies. It may even be the case that intermediary goals are in direct conflict with the ultimate goal. An example is insomnia therapy where bedtime restriction instructs the coachee to sleep less at first so they grow more tiresome. This conflicts with the ultimate goal of sleeping better, we call these conflicting goals: necessary preconditions.

The criteria for reaching/staying in W_1 should be elicited from the action plan. This action plan is a vital part of the therapy (it is seen in all therapies and methods discussed above) since it provides the patient with a guide to help solve his problems. This guidance is based on scientific and professional knowledge of the therapist, and therefore more effective than trying to change on ones own.

Transitions   As mentioned, the transitioning between these states depends on many factors. The transitions can be divided into two categories; transition to W_1, and transition to W_0 (respectively A & B, and C & D in Figure 8). The first category contains the elements that can positively influence the behavioural change, while the second contains the negative influences.

For the positive influences Mohr mentioned 5 strategies: i) education, ii) goal setting, iii) monitoring, iv) feedback, v) enhancing motivation [79]. They are selected from the taxonomy by Michie on behaviour change strategies [55], and are very similar to the strategies selected by Beun to increase adherence in automated e-coaching: i) tunnelling, ii) adaptation and feedback, iii) simplifying supporting activities, iv) motivational support [13]. The tunnelling corresponds with the education of Mohr, and extends on this idea by making sure the coachee only receives relevant information. This concept also encapsulates the next two points of Mohr; goal setting and monitoring. Both of these are also elements recurring in all behavioural therapies and conversation techniques. Feedback and motivation are the final strategies and focus on tailoring the coachee's process. An important aspect and the lack of it a reason why many self-help books fall short [80]. Summarising, all of these strategies aim at increasing the ability and/or motivation of the coachee [19, 55].

On the other hand some of these strategies might also be negative influences. Some strategies might be experienced as negative by some and positive by others (i.e. active reminders, pointing out mistakes, comparing behaviour to others etc..). But the absence of certain strategies might also negatively influence the user's state (i.e. no social support, no rewards). Besides actively implementing these strategies, there are also external factors that influence the user's state. As mentioned before circumstances in ones personal life may affect the progress in the therapy. These may lead to regressing from a (intermediary) desired state to an undesired state. This is an important fact to consider when creating an e-coach so one can decide how to act upon regression during the therapy.

The tool is aiming to assist authors in creating an e-coach, with the abstracted model, as seen in Figure 8, as a foundation and thereby encompassing behavioural therapy, conversational techniques, and behavioural strategies to increase adherence to the therapy provided by the e-coach.

5 Generalisation of Self-Help Treatments

To develop a tool that will allow authors to generate an e-coach for behaviour change we need a framework that supports this generation. There are frameworks created on more conceptual/abstract levels [20], but on the more practical level most frameworks quickly became to complex for an author to work with [48, 68, 79]. In this section such a framework will be constructed by analysing self-help treatments. The general process of self-help treatments as described in Section 3.2 is the starting point of this generalisation. The most important communication modality of the e-coach will be the use of dialogue (see Section 5.1), which will be taken into consideration when dissecting the different phases. To make a distinction between the different exercise types several self-help books were analysed, this is further elaborated in Section 5.2. Each phase will consist of one or several dialogues that are generated based on variables filled in by the author, as well as input from the coachee. These characteristics are elaborately discussed in Section 5.3. The generated dialogue will be based on templates, so called interaction recipes, these are explained in Section 5.4.

5.1 Conversation-focused Approach

The pillar of the authoring tool is dialogue generation. Dialogue is used by the e-coach as support and guidance for the coachees and for improving the adherence to the coaching process (based on the therapies and techniques described in Section 2). It facilitates interaction between e-coach and coachee and allows for alignment through negotiation of the therapy plan, an example of an enabling behavioural strategy as described in our behaviour change model in Section 4. It also provides support and increases motivation of the coachee during the behaviour change process [81].

Since the tool is build upon dialogue, it makes sense to split the generation of the therapy into separate conversations. When dissecting the therapy there are roughly 3 components: i) opening, ii) intervention (consisting of exercises), and iii) closure. The first and last are the easiest to model and can both be captured in one conversation. For each exercise there is at least an introduction and an evaluation. Therefore we reach a total amount of conversations dependent on the number of exercises.

$$\#conv = 1 + (\#exercises * 2) + 1$$

Besides these conversations that make up the *happy flow* of the therapy, there are conversations that are outside of this flow and won't appear if the therapy goes according to plan. These conversations will be labelled as *constraints* (see [20]) and needs to be specified by the author (e.g. these are not necessarily generated by the tool). An example of such a constraint might be the trigger of a conversation because the coachee has not done an exercise for 3 days in a row. In such a conversation the coach might ask for reasons or give tips on how

to approach the exercise better. So the total amount of conversations can be captured in the following equation:

$$\#conv = 1 + (\#exercises * 2) + 1 + \#interrupts$$

Splitting the therapy into conversations does not only make sense on an abstract level but will also make the technical implementation easier. Since the tool will need to be accessible for people without technical knowledge a visual editor for the dialogues is required. By splitting the therapy into conversations the tool can give an easy overview of all the current conversations present in the e-coach application which makes it easy to spot what it might be lacking. Splitting the therapy into separate conversations enhances modifiability, since they are easily modified using the dialogue editor. Lastly the conversation focused approach also enables developers to easily extend the therapy possibilities by adding support for tools, if there is a need for a very specific one.

5.2 Analysis of Self-Help Treatments

The intervention phase of the therapy is the hardest to generalise. Each treatment takes a different approach and therefore the exercises will vary between treatments. Since our tool aims at a generalised framework to build e-coaches it will have to support a variety of exercise types out of the box. To determine on those exercise types several self-help books and several studies on electronic interventions were analysed. They were across a variety of therapy domains (stress [82], weight loss [83], alcoholism [84,85], insomnia [20,86], depression [87]) to ensure variability. The self-help books were the starting point. They were first read to get a general idea of exercise types that were utilised during the treatments, after which each book was analysed in detail. In total we made distinction between 5 exercise types:

1. **Tool/Conversation**: There are hundreds of different tools available for all kinds of health treatments. The same goes for conversation based exercises, conversations can vary so vastly there is no meaningful way to create a generalisation of those. We knew beforehand these exercises could not be generalised and therefore will not be included in the authoring tool.

2. **Instructions**: These exercises appeared in every treatment we looked at. The coach instructs the coachee to execute a specific tasks. This can be a repetitive or a single task.

3. **Monitoring**: Similar to the instructions, but a coachee has to keep track of the progress by specifying the number of repetitions he has performed.

4. **Questionnaire**: A set of questions listed to provide the coachee with insights into their own behaviour, based on the answers they have given.

5. **Evaluation**: An exercise to help the coachee reflect on his action and progress of the behaviour change.

Table 2 shows the total number of exercises for each type. A breakdown per book we analysed can be found in Appendix A.

Tool/ Conversation	Instructions		Monitoring	Questionnaire	Evaluation
	Once	*Repetitive*			
9	18	7	7	15	10

Table 2: Analysis of self-help books (total #exercises per type)

Besides the self-help books, several studies on web-based or mobile interventions regarding e-health were analysed on their use of exercises types within the treatment. Table 3 shows an overview of the type of exercises that were used in those studies. This table does not show the number of occurrences since the treatments were online and many of the exercises repeated themselves based on how long the participants took part in the treatment. Another reason is the adaptive nature of these treatments, meaning each participant may encounter their own set of exercises.

Study	Tool/ Conversation	Instructions	Monitoring	Questionnaire	Evaluation
Gabriele et. al. [83]	X	X	X		X
Schaub et. al. [85]	X	X	X	X	
Griffiths et. al. [87]	X	X		X	X
Beun et. al. [20]	X	X	X		X

Table 3: Overview of the present exercise types in several studies

Gabriele et. al. gave the participants 3 tools to track their physical activity, food intake, etc. They also got weekly instructions from the e-coach, and a weekly evaluation for which the participants had to monitor their own weight loss progress [83].

The alcohol reduction study by Schaub et. al. first used an online questionnaire to give participants insight into their own drinking behaviour. They then followed up with a 6 week monitoring tool which simultaneously provided information on the dangers of consuming (too much) alcohol. The trial was finished with a conversation with a therapist in person [85].

Griffiths et. al. created a web-based intervention to reduce depression and anxiety. They first let participants fill in a questionnaire to get a baseline score of depression. The scores were based on two scales (Kessler Psychological Distress Scale [88] & Their own scale for depression stigma). The participants used MoodGym [89], a web-based tool for depression treatment. The website provides information on depression coping strategies and poses questionnaires to help participants visualise their own behaviour. Feedback is given through relating individual data of the questionnaires to normative data. Outside of MoodGym they contacted the participants weekly for a 10-minute conversation to ask how to perceived the tool [87].

A mobile e-coach for insomnia was developed by Beun et. al. and uses a sleepdiary as the main tool. In this diary participants keep track of their sleeping hours everyday. Besides the sleepdiary, participants are presented with relaxation exercises to ease their mind before sleep. Feedback is presented weekly during an evaluation conversation, this feedback is automatically generated based on several variables (sleep efficiency, hours in bed, etc..).

Conclusion

This analysis provides us with a starting point, for to exercise types, within mobile e-health applications. Since this is a generalising tool we want authors to have access to as many options as possible though we cannot provide every possible exercise as a built in feature. So this list of exercises is by no means exhaustive, though we feel it is comprehensive enough to provide a decent baseline for the authoring tool. We will go over each exercise type as described in Table 2 & 3.

Tools and conversations are excluded from our tool. There are hundreds of different tools available for all kinds of health treatments, these tools won't be an integral part of our tool unless an author decides to hire a programmer to implement such a tool. The same goes for conversation based exercises, conversations can vary so vastly there is no meaningful way to create a generalisation of those. The conversations we found in the analysis range from conversations with actual therapists about troubling feelings and thoughts to conversations with family members about the current living environment. Even though the conversation won't be automatically generated we will take their importance in mind and enable authors to easily create conversations using a visual editor.

Instructions were used in every treatment we looked at. Something is regarded as an instruction if the coachee will only have to execute the exercise. This can be something that has to be done once (at least in the context of the therapy), for example: cleaning your room. The caveat here of course is that one might make a mess of it again the next day. A solution for this might be to have the e-coach ask the coachee if their room is still clean everyday. Though one can imagine this will become annoying rather quickly. We therefore see exercises like that as an instruction to be executed once.

The second possibility is that of a repetitive instruction. An example of this is a daily relaxation exercise. The e-coach might want to keep track of how many times a coachee has followed through with the instruction to do a specific relaxation exercise everyday. This also implies the need for some sort of evaluation (why does the coachee does not follow through?, how do they feel about their progress themselves?, etc...).

Monitoring is similar to the instruction exercise though it requires the coachee to keep track of their progress in more detail. Rather than just providing information on whether or not the exercise has been carried out, the coachee needs to specify how many times he did a specific thing, or how much of it. Examples are: tracking hours slept, tracking weight, tracking miles walked.

The **Questionnaire** was mostly used to provide the coachee with insight into their own state. For example into their: behaviour, thoughts, beliefs, and so on. Another use for it was to determine if the coachee fits the target audience.

In the analysis **evaluation** was included as an exercise type, however we decided to exclude it from the exercise types. Evaluation refers to one of two things: i) an exercise, or ii) the whole therapy. In the first case, the evaluation is part of a certain exercise and therefore not a type of its own. And in the second case, the evaluation is part of the closure phase and not the intervention phase (see Figure 5.

When reading through the self-help books and the studies we also found a lot of them providing the clients with **tips and/or advice**. These tips were sometimes related to exercises or they were just general pieces of advice. Even though not all tips or advice will be actionable we decided to include it as an exercise to keep the overview for authors simple.

To conclude, our final list of exercise types:

- Monitoring

- Instructions

- Questionnaire to gain insight in own behaviour/thoughts

- Tips (Providing information/Giving tips or advice)

5.3 Deducing Characteristics of Conversations

To create a tool that will generate dialogue based on basic input given by an author a strong framework needs to be created. The tool will generate dialogue based on variables and text, which are to be filled out by the author of the therapy. By splitting the therapy into three phases and extracting variables from the books and apps that were analysed it is possible to generate a therapy that meets the characteristics of the therapies and techniques described in Section 2 and profits from the advantages an e-coach provides, without the interference of a programmer. The phases are based on Figure 5 (which is based on CBT) and the structure of the conversations is derived from an e-coach for insomnia, since this e-coach utilises the same division in phases. Conversations of their e-coach have been modelled as flowcharts to derive the structure, see Appendix B. Elements from motivational are found in the planning conversations for the exercises. This helps assigning autonomy to the coachee by letting him (co-)decide in his behaviour change process. The introductory conversations also help to clear up the whole change trajectory which is another important aspect of motivational interviewing. Questionnaires can be utilised to get insights in the readiness for change of the coachee. This can help to determine in what stage of change they currently are and if the therapy is suitable for them or not. Some complementary elements were added based on the analysis described in Section 5.2.

5.3.1 Opening

As seen in Figure 5, a therapy starts with an *introduction* where coach and coachee introduce themselves to one another.

After which the *therapy is introduced*, it starts with a **short explanation**, followed by the **purpose** of the therapy. Describing the **target audience** is important to prevent disappointment for starting the wrong therapy, not every therapy is suited for every person even if from a glance their problems might seem the same. In the model of Figure 5 this is referred to as *inclusion/exclusion*.

This is directly followed by managing expectations, explaining what someone can expect and helping him to set a (realistic) **goal**. The short explanation has to contain a few elements including (but not limited to): i) **length of the therapy**, ii) **number of exercises** and their **description**, and iii) **addressing frequently asked questions or concerns**. These are all part of the final part of the opening phase: *commitment*. Explaining all these aspects and helping the coachee in creating a realistic view of the therapy helps with the adherence to the therapy.

When comparing these characteristics to an actual implementation (Lyla-Coach [20]) it shows the same structure with the exception of addressing the frequently asked questions or concerns. They do, however, include concerns and side effects when explaining their exercises (in the intervention phase). All these characteristics are relatively easily addressed in books; the power of using an e-coach however lies in it's ability to interact and connect with the user [10, 14, 15]. Especially in the opening phase it is important to create a meaningful connection and establish trust between coach and coachee [43]. The coach should **introduce** itself and ask for some of the coachee's **details**, so it can initiate every conversation with a greeting and the name of the coachee. All the characteristics explained above are listed in Table 4.

Opening
E-coach name
Therapy description
Purpose of therapy
Target audience
Realistic goal
Length of therapy
Number of exercises and their description
FAQs
Details of coachee

Table 4: Characteristics of the dialogue in the opening phase

5.3.2 Intervention

The intervention phase consists of exercises that are to be performed by the coachee. Each exercise is considered a separate conversation and as discussed

in Section 3.2 it is made up of 4 main components. The conversation will start with an *introduction* followed by a *plan & commitment*, after which the coachee will start *executing* the exercise, *evaluations* will be held repeatedly to ensure the plan is well adapted to the coachee. Of these 4 components, all but the task execution require active involvement of the e-coach. Therefore an exercise conversation is made up of 3 main components: i) introduction, ii) plan & commit, and iii) evaluation.

When creating a generalised template compromises have to be made. The template should be general enough to make it applicable to different use cases (therapy domains in this case). However, it should also cover all important aspects of these treatments. In this case most of the variability is found in the intervention phase, within the exercises. Exercises may range from cutting down on cigarettes to using complex tools. Creating a generally applicable model implies drawing a line somewhere. Our authoring tool will not include exercises that make use of external tools, such as calculators for calorie intake or extensive monitoring tools, but rather focuses on (the more common) simple tasks. The tool will be developed with the use of tools in mind, striving to make the integration of such tools as effortless as possible.

In the analysis of existing treatments, we divided the exercises in four different categories:

- Monitoring

- Instructions

- Questionnaire to gain insight in own behaviour/thoughts

- Tips (Providing information/Giving tips or advice)

The first 2 categories will probably be the most complex to generalise [2]. They both seem relatively simple, though to implement them many factors have to be taken into consideration. A big challenge is the adaptation to personal ability levels. A way to achieve this is through negotiation [66]. This reveals the need for a negotiation mechanism that is both exhaustive and easily generated. Beun et. al. provide an example on how to approach negotiation in automated e-coaching, which will serve as the outline for the negotiation generation that is present in the tool [66]. The second two categories are simpler in the sense that they require less reacting to live input of the user. They require only information from the author of the e-coach and don't need an extensive system like the negotiation mechanism. The different nature of the exercises will also show up in the evaluation dialogue, they therefore need to be modelled separately for each exercise type as well. To conclude, the templates for the intervention phase will consist of:

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[2]Some exercises might fit in both categories, it is then up to the author to decide as what it should be classified. Monitoring exercises only make sense if the in-/decrease in certain behaviour is dependent on user ability. If there is no negotiation required about the frequency of the exercise is should be considered an instruction exercise. Example: stretching your arms in front of you 5 times, this can be considered doable for everyone and would therefore be classified as an instructions exercise

- General introduction

- For the *monitoring* and *instructions* exercises: plan & commit dialogue, and an evaluation dialogue

- For the *questionnaire* exercise: interface that shows questions, answers, and final results

- For the *provide information* exercise: interface that shows the information

Table 5 shows all the variables that were deducted from the analysis of the different exercises. The variables are split in: i) introduction dialogue, ii) a plan and evaluation dialogue for the monitoring and instructions exercise, and iii) the questionnaire and tips/advice exercises. How these variables were deducted will be discussed in the following paragraphs.

Introduction	M_Plan	M_Eval
Exercise Name	Intended Outcome	Coachee Feeling
Purpose	Temporary Goal	Weekly Average
Explanation	Starting Proposal	Negotiation Percentage
Time of Execution	Striving Goal	Agreement
FAQs	Negotiation Percentage	Reason
	Lower bound	Time of Execution
	Upper bound	
	Confirmation	

I_Plan	I_Eval	Q_exerc	T_exerc
Temporary Goal	Coachee Feeling	Purpose	Tips
Starting Proposal	Weekly Average	Set of Questions	Topic
Confirmation	Agreement	Context	
	Reason	Score	
	Time of Execution	Categorisation	

Table 5: Variables of intervention phase, listed by exercise type

Introduction   Every exercise needs to be introduced to familiarise the coachee with the exercise they are going to perform. It will start with the **name of the exercise** and a **reason/purpose** on why the exercise will benefit the coachee in their process of behaviour change. This is followed up by an **explanation** on how to perform the task(s) at hand. For example; how to track your sleep, or how to carry out relaxation exercises. It helps to let the coachee determine a **set time** at which he will perform the exercise [90]. And finally the e-coach should list a set of **questions** that the coachee might want to address, such as *"what will I get from this therapy"*, or *"What should I know before starting"*. These questions may vary a lot between therapy domains.

Monitoring Planning   A *monitoring* exercise where the coachee keeps track of how many times they executed a certain task. The goal of this exercise has multiple possible outcomes, it may try to reduce the current behaviour (e.g. smoking less cigarettes), increase the current behaviour (e.g. walk more kilometres), or increase/decrease it within a certain interval (e.g. sleeping hours should never go below 5 nor exceed 8/9).

So first, the **intended outcome**, should be selected (e.g. increase or decrease targeted behaviour). If it is clear whether a coachee should increase or decrease in a specific behaviour, perhaps within some boundary, the negotiation algorithm will negotiate a first **(temporary) goal** with the coachee. The author of the e-coach is able to tweak some settings of the algorithm such as: **starting proposal** (if omitted, coachee will make the first offer), **goal to strive for** based on therapeutic experience or research (if omitted the algorithm will aim to just increase/decrease, or aim for a **minimum/maximum**), and the **percentage** by which the e-coach will increase/decrease the offer made by the coachee. The planning and committing phase is finished with motivational support and encouragement, and a **confirmation** of the coachee to dedicate himself to the exercise.

The negotiations utilise an algorithm that determines the responses of the e-coach and the sets the coachee's goals for the exercise. An in-depth breakdown of these algorithms can be found in Appendix C.

Monitoring Evaluation   The second conversation for a *monitoring* exercise, is the evaluation. The evaluation is iterative and takes place every week for the whole duration of the exercise. In the evaluation, the e-coach will ask the coachee about his **feelings** towards the execution of the exercise. The feeling of the coachee will be related to the **observed performance** by the system. This means that the values the coachee has filled in throughout the week will need to be analysed.

In an ideal situation each day will be analysed separately and the e-coach will react accordingly. For example, if a coachee meets his/her goal 5 days of the week but performs poorly the other 2 days, in the most ideal situation the e-coach would specifically ask the coachee what happened those 2 days. This, however, is not feasible when creating a general model since it will exponentially increase the possibilities that all have to be modelled and included in the dialogue templates. So, the value that will be used as a reference as to how well the coachee performed their exercise will be the **weekly average**.

To reduce the conversation possibilities even further it was decided to categorise the weekly average into three categories: i) bad, ii) reasonable, iii) good. The system can't arbitrarily decide whether something is bad, reasonable, or good. This means that the author of the e-coach must decide upon a **percentage** that will determine in which category a value will belong.

To reason about the result the coachee is asked how they felt the exercise went the past week. This **feeling** will also have to be categorised and we opted for four options: i) really bad, ii) not so good, iii) decent, iv) really good. The

reason we went with four choices is the limitation of the conversation space. By limiting to four choices for the coachee and three for the categorisation of performance we limit the conversation options to 8, two for each option the coachee may select: agreement, or disagreement. Whether or not an e-coach and coachee are in agreement is determined using the scheme as seen in Figure 9.
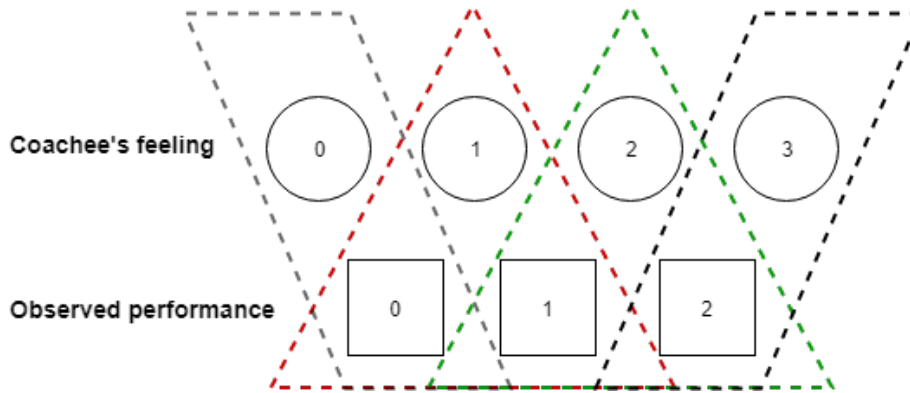
Figure 9: Visual representation of the agreement between e-coach and coachee in an evaluation dialogue

In this figure the feelings of the coachee are represented by the numbers 0 - 3, going from really bad to really good. The observed performance is similarly represented by the numbers 0 - 2, going from bad - good. To capture it in a formula we state e-coach and coachee are in agreement if and only if:

$$coachee\_feeling - 1 <= observed\_value <= coachee\_feeling$$

To illustrate this with an example, let there be a treatment that helps coachee to get fitter. This exercise is about doing a certain amount of pushups. The author of the e-coach has decided on 20%(=0.2) to categorise the performance, and the goal of the coachee was 15 pushups a day. The coachee selected 'really good' (3) as his feeling towards the execution of the exercise this week.

- Day 1-7: 12, 15, 18, 12, 14, 14, 16

- Weekly Average: **14.4**

- Bad: $<= goal * (1 - percentage) = \mathbf{15 * (1 - 0.2) = 12}$

- Reasonable: $Bad < x < Good = \mathbf{12 < x < 15}$

- Good: $>= goal = \mathbf{>= 15}$

- Coachee Feeling: Really Good = **3**

In the case of our example, the weekly average will be scored as **reasonable** (*1*) (between bad *(12)* and good *(15)*, based on the percentage specified by the author). When we map this to our scheme in Figure 9 and the equation that determines the agreement we see e-coach and coachee are in disagreement. The e-coach will now respond accordingly by telling the coachee he might have overestimated his performance based on the numbers that he entered into the system.

The drawbacks of this system mostly show when dealing with edge cases; if the coachee selected '*not so good*' and the observed performance comes just 1 short of the '*good*' category one could argue the coachee is underestimating his own performance even though the system acts as if feeling and observation are in agreement with each other. This is unavoidable unless every option is separately written out into the dialogue tree. Compromises between accuracy and ease of use/clarity have to be made, this system significantly reduces nodes in the dialogue tree while still presenting the coachee enough options to make him feel heard.

If the feelings of the coachee and the observations of the system are contradicting each other (based on the equation we specified earlier) or if the coachee performed bad the coachee is presented with a few options: i) he can opt to change the **time** of the notification for the exercise, ii) give a **reason** for not doing so well, or iii) say they do not know why he performed poor or why he felt like he did so. If the coachee specified a reason (which is done through filling in a simple text box) the e-coach will repeat this during the next evaluation round. This is based on the principle of the client-centred approach suggested by Carl Rogers in the 1960's [91] (the same principle that was used to create Eliza, the world's first electronic psychotherapist [17]).

After the system has decided which path through the dialogue tree to pick, it will start the renegotiation. As discussed the goal of the renegotiation is to tailor the therapy to the level of the coachee [46]. The renegotiation algorithm, is similar to the negotiation part of the algorithm used in the planning phase, with the difference of making use of observed results of the coachee. Appendix C contains a dissection of the algorithms.

Instructions Planning The *instructions* exercise is relatively less complicated to model, than the previous one. The negotiation part only concerns how many days a week the exercise is executed. The default value will be 7, since most exercises are best performed each day of the week. This is substantiated by several studies on habit formation showing repetition being the key to forming new habits [92, 93]. Because of the importance of repetition and the fact that most exercises lose their point if not performed regularly, the minimum is set at three times a week. Apart from that the algorithm works the same as for the monitoring exercise, there are just less variables to tweak (e.g. the intended outcome is never aimed to decrease, the striving goal is always seven, and there is no percentage the e-coach rather just tries to increase the frequency by one day). This is only asked once to prevent the e-coach from seeming like

a wiseacre. The algorithm is, again, explained in Appendix C.

Instructions Evaluation   The instructions exercise will also contain an evaluation dialogue. The evaluation starts with the same mechanism as shown in Figure 9. After which the e-coach determines if renegotiation is needed. The renegotiation will address the times the exercise was executed rather than how many repetitions, which was the case with the monitoring exercise. Since there is no sensible use for a strive goal specified by the author for the instructions exercise, the renegotiation algorithm resembles the *monitoring* evaluation algorithm very much. First it checks if the coachee stays above the minimum amount, followed by a check if there is room for improvement (e.g. is it below the maximum), and finally if he is already at the maximum he is appraised and the goal remains the same. As with all other algorithms, it is further elaborated in Appendix C.

To summarise, the planning and evaluation structure of the exercises *monitoring* and *instructions* contains two algorithms: (re-)negotiation and evaluation. It is an iterative process and can be captured in the following figure:
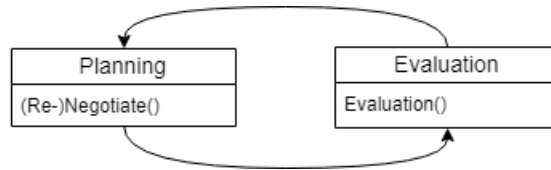
Figure 10: Simplified overview of the planning and evaluation in *monitoring* and *instructions* exercises

Questionnaire   As mentioned in Section 5.2, whether the next two paragraphs should be regarded as exercises is debatable, however we chose to label them as such since they are a recurring element in the self-help books and it will help to keep things clear for the author. It might become confusing to add even more terms, especially when they first start out using the tool.

The **questionnaire** is used to provide the coachee with insights in their own behaviour or thoughts. This helps to make them aware of their own (possible) shortcomings, or helps them to visualise what their current situation is like. This visualisation may be useful for clients who are still in the precontemplation phase as well (see TTM in Section 2.3). Another use is determining if the coachee is part of the target audience, by having them answer questions about their current behaviour.

The questionnaire consists of a **set of questions**, optionally accompanied by some **context** explaining the questions and/or answers. The author also specifies the **purpose** of the questionnaire, like the ones mentioned above.

To each answer the author assigns a **score**, after which the author provides **categories** with certain scoring ranges to determine in which category

the coachee should be classified. Each category will have it's own description, which possibly contains some advice as well.

Tips Another recurring item in the books was the use of **tips** or advice. Which is basically just providing the coachee with information. This information might for instance, concern the environment in which an exercise is to be performed or provide extra tips on how to adhere to the therapy.

So, this exercise is just an overview of the **advice and tips** the author wants to give to the coachees. To keep things organised and clear the author will need to pick what **topic** the tip relates to. This is either a specific exercise or just a general tip.

5.3.3 Closure

The conversation for the closure of the therapy is kept rather simplistic. Since each treatment has a different aim, the dialogue template should be kept general. If we are looking at the model in Figure 5, it shows the 3 aspects of the closure phase: i) evaluation, ii) referral, and iii) departure.

The evaluation will be a question on what the coachee's **feelings** are towards the treatment. And will serve as a final means to show the coachee his opinion is heard, within his therapy-session not much is done with the actual answer. This answer might be useful to store somewhere if the designer of the e-coach wants to gain insight in the opinion of the users.

The referral is optional and will probably be mostly used in therapies that try to change malevolent behaviour. Because, if the e-coach did not help in changing the behaviour the coachee might need to go see a therapist/specialist in person. The e-coach will deliver a **message** trying to convince the coachee about the destructiveness of his behaviour. Other referrals might include but are not limited to: referring to a self-help book the author has written, referring via a **link** to a website that contains more information, or referring to therapies in other domains (by the same author).

The departure consists of saying **goodbye** to the coachee, thanking him for his participation and express the e-coach's hope that the therapy was useful for him. If not, or if the coachee wants to leave any other feedback the e-coach will conclude with a form to leave any additional **feedback** for the e-coach/app. This feedback can then in turn be used by the authors of the e-coach to improve the experience of the coachees. An overview of the characteristics in the closure phase can be found in Table 6

Closure
Coachee Feeling
Referral Text
Referral Link
Departure Message
Coachee Feedback

Table 6: Characteristics of the closure phase

5.4 Conversation Templates

In the previous section we discussed the structure of the dialogues and how these are completed by the variables of both e-coach creator and coachee. In this section, the templates used for the generated dialogues will be handled. For easy reference and overview, the same layout as in the previous section will be used. First, we will discuss the opening, followed by the intervention (with its corresponding exercise types), and finally the closure phase.

The term interaction recipes is lent from the paper by Beun et. al. [20].

> "*Interaction Recipes* are the central entities in the specification of a
> conversation. They represent one e-coach turn in the conversation
> and end with one or more options indicating the coachee's turn."

Our implementation differs slightly, we opted to let the authors build-in several turns in one interaction recipe. This has be decided to keep the clarity within the authoring tool. Having 6 separate flowcharts for just 5 rounds of conversation might confuse the author. It is also more clear to have an overview of all paths through the dialogue tree within one flowchart. The interaction recipes can be considered as templates, though we refer to them as recipes since they can be edited by the authors of the e-coach, as well as be created from scratch. Each interaction recipe can be modelled as a flowchart, which is a *directed graph*. The path that is taken through the chart is defined by either user input (choices) or by system logic (branches). This system logic will be in the form of if-statements (i.e. "if x then y; else z"). To construct the conversations we need different node types. For example we need to be able to send a message to the coachee, but he also needs to be able to respond. To cover these aspects an interaction recipe is build up out of 5 node types[3]:

- E-coach Message (Supply the coachee with information)

- Coachee Input (Setting a variable -> Using direct user input)

- Coachee Choice (Coachee picks a choice -> determines path in dialogue tree, or sets a variable)

- Set Variable (Setting a system variable -> Using a path in the tree to set a variable)

---

[3]These node types are explained in more detail in Section 6.1.2

- Branch (Splitting in the dialogue tree based on system variable)

The interaction recipes created for all standard conversation are based upon the conversations from LylaCoach [20] as seen in Appendix B, and the characteristics we deduced in the previous section.

For the visualisation of interaction recipes we picked different colours for the different node types. The colour representation of the nodes is shown in Figure 11 and has no other function but to show which node type is represented in the flowchart. All interaction recipes can be found in Appendix D, to keep the report organised.
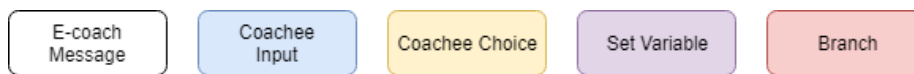
Figure 11: The different colours and the nodes they are representing

6 CoachLab

To substantiate the model by implementing it in a tool we present CoachLab. A 'laboratory' for creating e-coaches with no technical know-how required. The tool will guide the author through the process of creating an e-coach and automatically generate a dialogue-based therapy based on industry-standard behavioural therapies and conversational techniques as discussed in Section 2. Since the therapy is based on current literature and is automatically generated, authors do not need any technical knowledge to create an e-coach. If the designers find something in the dialogue that is not to their liking it can be easily adjusted in the visual dialogue editor.

6.1 Modelling CoachLab

The e-coaches created with CoachLab will be modelled as autonomous agents, possessing traits comparable to a human coach, like providing feedback and negotiating. The e-coaches are all created by domain-experts (therapists, or authors of self-help books) and should therefore be able to convey this knowledge to the coachees. The e-coaches are able to adapt the treatment to individual people, offering effective treatments to the coachees based on their abilities. Because of the way dialogues are structured and the treatment is set up, the e-coaches are able to motivate and encourage the coachee in their behaviour change process. By enabling the coachee to make autonomous decisions, through mechanisms like negotiation and feedback-loops, treatment adherence is increased [13].

The architecture of the e-coach is modelled after the *Belief, Desire, Intention* (BDI)-structure [94]. The *beliefs* of the e-coach are based upon his domain knowledge. This contains elements such as: the information about the coachee, the current coachings process and information on scheduling. All these *beliefs*/this information is stored in the knowledge repository (see Section 6.1.1).

The *desires* are reasons that specify what behaviour is appropriate. In our case this is represented by the constraints and scheduling mechanisms, each of these can initiate a conversation based on certain requirements. Since CoachLab focuses on e-coaches for behaviour change, the *desire* of the e-coach is aiding the coachee in this process, this *desire* will not change. To fulfil this *desire*, the e-coach holds a set of *intentions*, which can be viewed as a set of actions. These actions are based on the existing behavioural therapies, the behaviour change process and the interaction recipes as described in the previous section. This set of actions is not set before-hand since it may need to be adjusted to the ability level of the coachee.

Figure 12 shows the first draft of the architecture of CoachLab. Since the scope of this project is limited to the conversation design and creation of the dialogue editor some elements might be prone to change. CoachLab contains five main elements: i) *constraints*, ii) *schedule*, iii) *interaction recipes* , iv) *knowledge base*, and v) *dialogue-editor*. The knowledge base is the centre part of the authoring tool, other elements require the variables that are within the knowledge base to function. Section 6.1.1 will elaborate further on the knowledge base.
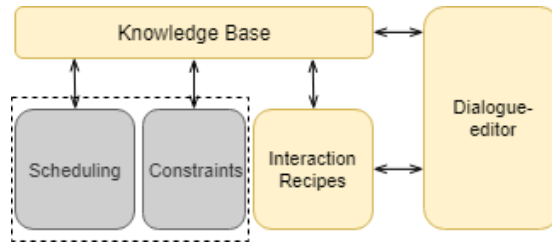
Figure 12: The architecture of CoachLab.

The scheduling and constraints mechanisms are added to the architecture since the e-coach modelling is based on the constraint based model by Beun [20]. This part is not yet implemented and will therefore not be discussed in great detail. It is clear however, that there needs to be a scheduling mechanism to determine which dialogue is instantiated when. And besides the scheduler instantiating dialogue there will be exceptions on which the e-coach should act. An example of such an exception is the absence of the coachee for more than a specified amount of days. These exceptions can be modelled as constraints which trigger an action upon violation.

6.1.1 Knowledge Repository

The knowledge repository is the central section of CoachLab. All other elements make use of it and it contains all the variables needed in the therapy. The author can use this database to personalise conversations by utilising those variables. Through an initial form where the author fills in some of the characteristics (as described in Section 5.3) several basic variables are automatically generated. The same goes for the instantiating of exercises: an initial form is filled in and variables standard for that exercise are generated.

Since CoachLab is a tool that is based on a generalisation of the coaching process, it will not generate every possible variable an author might need, therefore the author is able to expand the knowledge repository according to their needs.

A therapy can quickly contain tens if not hundreds of variables. As seen in the characteristics section, a single monitoring exercise contains around 10 variables. This portrays the need for categorisation. Since our focus is on a conversation-based approach it seems logical to label the variables based on which conversation they are part of. This takes of care of most variables though some are general variables and will likely be used across the whole therapy (e.g. coachee's name, age, etc..). Every author might have a different perspective on the grouping of the variables, so to ensure flexibility within the tool we use a labelling system that is editable by the authors. They can create their own labels, and change/add labels to existing variables.

6.1.2 Interaction Recipes

As described in Section 6.1.2 one of the main components of CoachLab are the interaction recipes. They can be considered as templates, though we refer to them as recipes since they are editable by the authors of the e-coach. The interaction recipes make up a full conversation between e-coach and coachee. Though several recipes might be part of one section of the therapy. An exercise might have an introduction and evaluation for example. An interaction recipe is basically a tree-like structure (a short example can be found in Figure 13), that consist of 5 different types of nodes:

- E-coach Message (Supply the coachee with information)

- Coachee Input (Setting a variable -> Using direct user input)

- Coachee Choice (Coachee picks a choice -> determines path in dialogue tree, or sets a variable)

- Set Variable (Setting a system variable -> Using a path in the tree to set a variable)

- Branch (Splitting in the dialogue tree based on system variable)
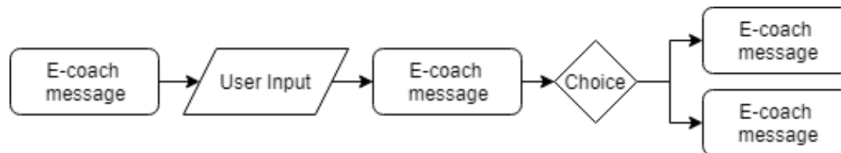
Figure 13: Example of the tree-like structure of an interaction recipe.

Each node serves a different purpose and should have a different appearance to make sure the author can easily recognise which type of node he is dealing with.

E-coach message is the most straightforward since it is made up of only text. As seen in Section 5.4, these bodies of text can contain variables. These variables may be designer input, coachee input, or system knowledge.

Coachee Input asks the user of the e-coach application to fill in a value that will be assigned to a variable. Examples of these might be their name, age or a reason for their lack of performance this week.

Choice will determine which path to follow in the tree of the conversation. Sometimes accompanied by setting a variable in the progress. An example is the feeling of the coachee towards his execution of the exercise this week. This choice is followed by a proper response but might also affect how the negotiation is handled. Or it provides a branch with its value somewhere deeper in the dialogue tree.

Set Variable is a node used to assign a certain value to a variable based on the path within the dialogue. It makes the most sense to use these after a choice by the coachee. If the author wants to keep track of the 'assertiveness' of the coachee, this node can be used to set a value for each choice the coachee can make. This variable might later be used to split on using a *Branch*.

Branch is the final node type and it is used to split the dialogue tree based on variables. Sometimes there is no user input that triggers a split in the dialogue tree. This will mostly be used when a variable (set by either *Coachee Input* or *Set Variable*) that was set earlier in the therapy, will be used later. The e-coach can use this to refer to earlier beliefs of the coachee about his state.

The interaction recipes also utilise the negotiation and evaluation algorithms as described before in Section 5.3. The algorithms take several variables and automatically adapt the algorithm to their values. This allows the e-coach to negotiate on a lot of different topics and with different intended outcomes.

6.2   Technical Specifications

Now we have an overview of the requirements for the tool and the e-coach, decisions on an implementation level are required. The tool consists of three main parts: i) the tool itself, used to generate the therapy, ii) a visual editor for the dialogue templates, and iii) the application that it generates, i.e. the e-coach. Preferably the selected languages/tools are well-documented and known to us beforehand. The tool will be either web-based or a stand-alone application, it would be ideal if choosing between these can be done in a later stadium. We should be able to easily generate the final application (the e-coach) for both Android and iOS, and the software should be freely available for educational use. The authors are not expected to be able to code, therefore the need of a visual tool to adjust the dialogue templates arises. Since the dialogues are structured like a tree, a graph/flowchart-editor (preferably one already designed for dialogue) makes the most sense.

To summarise:

- Two parts: main tool and generated e-coach application

- Programming languages and frameworks are well documented

- Choosing between web-based and stand-alone in a later stage

- Generate final application for Android and iOS easily

- Freely available for educational use

- Visual editor for Dialogue

- Easy import and export of Dialogue trees within the tool

With these requirements in mind, JavaScript (JS) immediately surfaces. It is an easy language with an extensive set of frameworks and libraries around it. And with a community that is very large (JavaScript is used on pretty

41

much every website nowadays), there is plenty of documentation on all of the important libraries. JavaScript is mostly used on front-end design in website development and is therefore ideal for our tool since the tool is functioning fully around user-interaction. Even though JavaScript was designed for front-end web development libraries like Node Webkit or Electron enable exporting it to a stand-alone desktop applications, so that is covered as well.

Another JS library is React and more specifically React Native [95], this library allows developers to generate Android and iOS from JavaScript code. These libraries are also free to use, so React Native is the main developing framework that will be used for this tool.

For a visual graph/dialogue editor there exist a lot of tools. There are tools created specifically for dialogue generation, most of these are used for the creation of text-based adventure games. Not every tool however suited our needs. Some of the tools that were examined include: Twine, Whiskers, and the Poor Man's Dialogue Tree. We went with the latter because of its simplicity and effectiveness [96]. The editor is open source and actually contains all but one node types that were specified in 6.1.2 plus an extra he specifically needed in his game. The tool is created using JointJS which is well-documented, allowing us to adjust things relatively easy if needed.

This results in a relatively simple software architecture, as seen in Figure 14. For the user interface we used a framework called Ant-Design [97], this simply allows us to use built in interface-features like timelines, drop-down menu's, etc.., without having to code it ourselves.

We see the author interacts with the *React Native*[4] application through the user interface, which is created using the *Ant-Design*[5] framework. Part of this application is the *Poor Man's Dialogue Tree*[6], which we will discuss in Section 6.2.2. In Section 6.2.1 we will discuss the advantages of React Native, one of which is seen in the architecture: generating Android and iOS native applications. This means all the e-coaches that are created using CoachLab will have support for both Android and iOS.
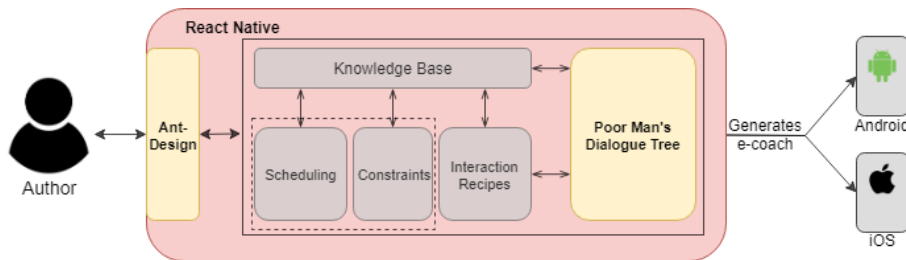
Figure 14: The software architecture of CoachLab

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[4]React Native framework can be found at: https://www.reactnative.com/

[5]Ant-Design can be found at: https://ant.design/

[6]The Poor Man's Dialogue Tree can be found at: https://github.com/etodd/dialogger

6.2.1 React Native

As described JavaScript can be a powerful coding language if the right libraries and frameworks are used, and if they are used for the right purpose. Since our tool does not have to do very complex computations in the background it is a great solution for our goal. In our case there are a lot of advantages to using React Native:

- **Simplicity** - React is even simpler to understand than regular JavaScript because of its components-based approach and its well-defined lifecycle (which enables reusability). The syntax used in React is JSX which enables the mixing of HTML and JavaScript, accomplishing the component-based approach. If author might opt for a programmer to help them it is easier to find one for React since it only requires basic HTML, CSS, and JS knowledge, unlike other frameworks like Angular or Ember.

- **Reusability Support** - Especially for the creation of mobile applications reusability of code is very important. This aspect of React Native allows us to make iOS, Android, and even regular Web Applications.

- **Maintainability** - Due to its component-based nature and the reusability of components, there is less duplication and overhead, making it easier to maintain the application.

- **Debugging** - Due to the way React handles data binding (one-way) and its use of components it is easier to debug these self-contained components.

- **Statefulness** - React applications allow for easy testing. React is stateful which means react views can be treated as functions of the state, allowing for manipulating which state is passed to the view. Which in turn shows the output, or actions, events, and functions that are triggered.

- **UI Frameworks** - Since React is a tool to create front-end design focused on interaction there are a plethora of frameworks for User Interfaces. This helps speed up the development process, allowing us to reuse existing UI elements like timelines, drop-down menus, forms, etc.

Concluding, React contains many features that allow us to develop more easily and take things off our plate. If new people will join in on the project, the maintainability and simplicity of React will help them work on it quicker.

6.2.2 Open Source Dialog Editor

The tool will not just generate an e-coach application based on some variables and dialogue templates. The author needs to be able to adjust the dialogues to its own liking. To achieve this, without the need of knowledge about React or programming, a visual editor is required. We are assuming authors are familiar with direct graphs, or will at least quickly see the structure/flow of a dialogue.

For this we selected an open-source visual dialogue editor created by a game-developer [98]. The editor already contains all but one (coachee input) of the node types specified in Section 6.1.2, making it perfectly suitable for our tool. The editor runs as a desktop application using node-webkit, so a way to load it inside our tool is needed. Preferably the design of the dialogue editor will also be adjusted to fit the design of CoachLab.

The dialogue editor is based on another open-source JavaScript framework called JointJS [99]. This framework specialises in the creation of graphs, especially in dynamically generating/creating them. It is an eminent tool for our purpose, since the goal of our dialogue editor is enabling the author to quickly and easily create and adjust dialogue templates. These two frameworks enable us to build on proven UI mechanisms creating an application with a smooth user experience, and a professional feel. For the UI framework we chose to work with

7 Designing Conversations in CoachLab

The dialogue editor within CoachLab is used to create or adjust conversations to be used by the e-coach. As discussed in Section 6.2.2, the dialogue editor is based on an open source project. We used the basic structure to build on and extend with the functionality we needed to design our conversations. We did need to restructure the nodes for the *E-coach Message* and *Set Variable*. Besides that we created a new node that would provide the coachee with an input form and assign that input to a variable: *Coachee Input*. The following changes were made:

- *E-coach Message*: The tool only supported one line of clear text input. A button to add a variable was added to allow the author to quickly insert a variable. To show the author they added a variable to the text, the variable is shown in a coloured label, see Figure 15.
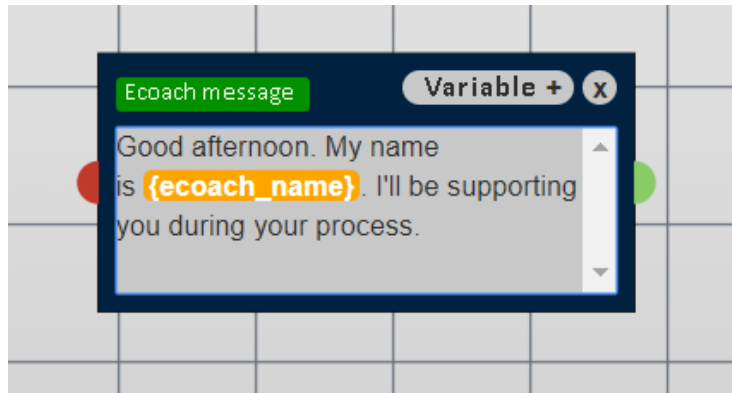
Figure 15: Labelling of variables in the e-coach message node.

To ensure the existence of a variable, an author may only pick a variable from a list that is generated based on the variables in the knowledge base. Since the amount of variables can increase rather quickly a filter was added to search through the variables, see Figure 16.
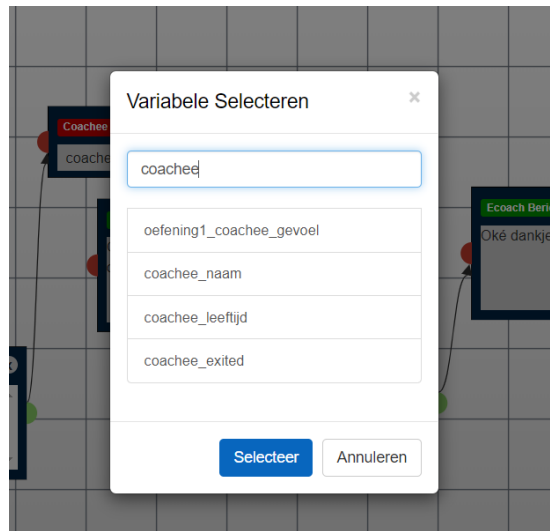
Figure 16: Selecting variables for the e-coach message node. (Filtering on: 'coachee')

- *Set Variable*: The existing node for setting a variable allowed the author to fill in anything they wanted for the name of the variable. Again, to prevent mismatching of variables we opted for a list (in the form of a drop-down menu) of the existing variables to select from.

- *Coachee Input*: This node did not yet exist within the dialogue editor. It was relatively easy to implement, it uses the same drop-down menu as in *Set Variable* and just leaves out the field for the value, since the value will be whatever input the user provides.

An author has two ways to open the dialogue editor: i) by opening an existing conversation, ii) by creating a new conversation. When they decide to open a new conversation the dialogue editor will show the dialogue-tree that makes up that conversation. An example of such a view can be found in Figure 17. If the author wants to create a new conversation the grid will show up empty. The adding of nodes is done through the menu in the side-panel.
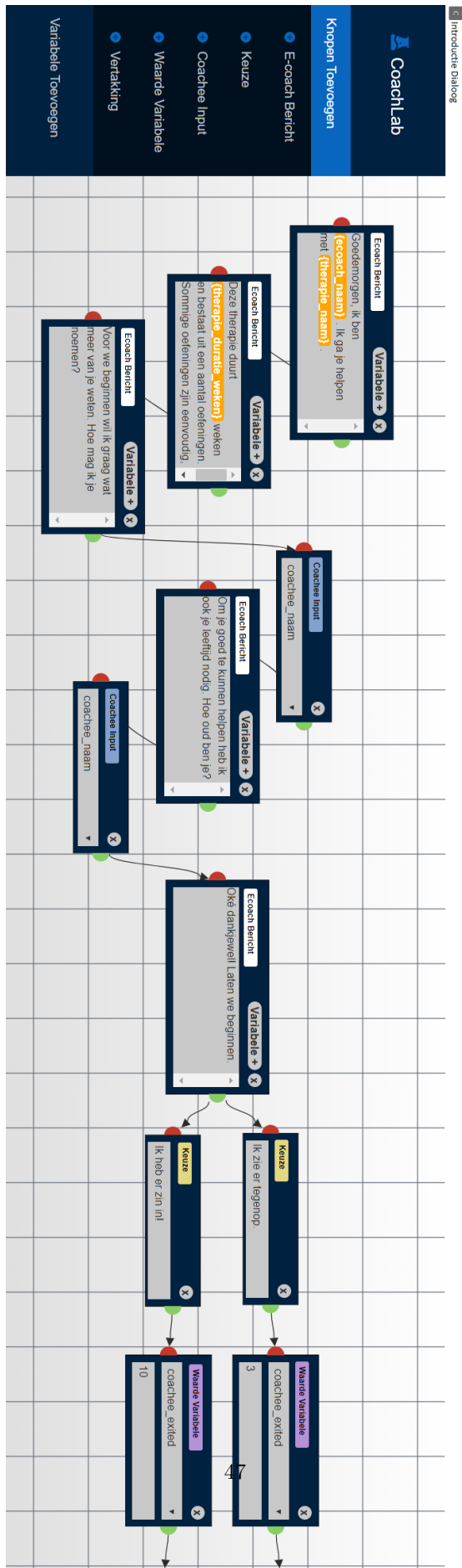
Figure 17: An example of a dialogue in the editor.

By clicking the "Add Nodes" button the node types will fold out and by clicking a node type it will be added to the grid. By dragging them and connecting them with other nodes a dialogue tree can be created. Each node type has its own label to distinguish between different node types, see Figure 11. The lines show the transitions between different nodes, and make up the different routes a dialogue can take.

The second button "Add Variables" allows the author to add variables to the knowledgebase. Since we are restricting authors to only select variables that are present in the knowledgebase, they do need a way to add variables to the knowledgebase. A simple form is presented when the author wants to add an extra variable to the knowledge base, see Figure 18.
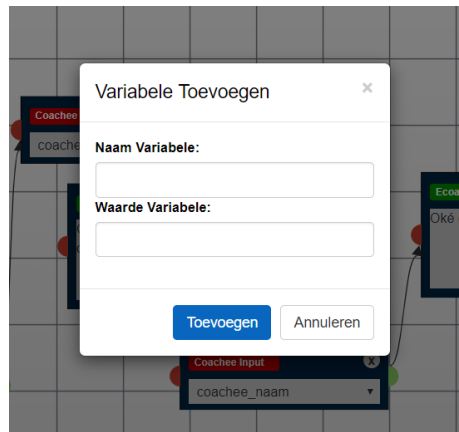
Figure 18: Adding a variable to the knowledgebase.

The layout and UI is based on Ant Design [97], a UI framework for React, which is also used for the rest of CoachLab. This to create a seamless experience and really make the tool feel as an integral part of CoachLab.

7.1 Evaluation Design

To evaluate the dialogue editor usability tests were performed. Evaluation confirms that the product will work as it is supposed to, or if it needs refinement. It allows us to assess the viability of the design and helps us identify potential caveats. Since it is relatively early-on in the implementation process our focus is on the usability of the tool. By testing the usability we will get insight in how easy to use the tool is, and how well people will perform.

- **Test Product**
  During the evaluation we will be testing the dialogue editor of CoachLab. This is the editor within which authors can edit, or create completely new conversations for the e-coach.

- **Test Objectives**
  We want to see if people are capable to create simple conversations using the dialogue editor. Specifically how they make use of the variables (adding them and using them in the text) and how easily they realise which node serves what purpose.

- **Participants**
  Since it is the first usability test we decided on targeting users who are already somewhat familiar with technological concepts such as variables, to prevent too high of an entry barrier. The participants were all student, or had recently graduated. Their age was in the range of 22 - 26, and they all did a study related to information sciences (Information Science, Media Design, Computer Science). The participants were reached via personal connections and received no further incentive to complete the test.

- **Equipment**
  The test was executed on a laptop with the application pre-installed, with an external mouse so they did not have to use the trackpad. The results of the participants are saved to the laptop via screenshots.

- **Test Tasks**
  The task-set that was created for the participants can be found in Appendix E.1. It consists of creating a dialogue within the editor, making use of existing variables and creating new ones.

- **Responsibilities**
  During this test, it is our responsibility to observe the participant and assist where necessary. As developer of the application we will also assist if any technical problems may occur.

- **Location and Date**
  The tests all took place on the 23th of July. The participants were in an enclosed space without distracting noises during the test.

- **Procedure**
  First we gave a short introduction on the purpose of the test and what we walked the participants through their consent form. They then got the time to read through the document and were told to give a sign when they reached the "Assignment"-part of the document. When they were done reading we presented them with the laptop with the application already running. They were then instructed to follow the instructions of the assignment and to let us know when they were done. Once they finished, their results were captured via a screenshot and they were presented with the survey. They filled in the survey and that concluded the test. During the test, observations that were deemed important were noted.

- **Results**

  The correctness of the model will be measured by looking at precision and recall, both of which are measures on relevance. Precision is the fraction of relevant instances among the retrieved instances (i.e. how many of the nodes and variables selected by the participants are present in the golden standard). Recall is the fraction of relevant instances that have been retrieved over the total amount of relevant instances (i.e. how many of the nodes and variables in the golden standard have been selected by the participants).

  As a final task to measure the usability participants have to fill in a survey. The SUS-score is a well-known and widely used metric to measure early usability performance [100] (for clarity the questions of the SUS-survey are added in Appendix E.2). With help of the precision, recall, and SUS-score, together with the behavioural data captured during the evaluation, we will be able to get a first impression of the usability of the dialogue editor in CoachLab.

7.2 Results

In this section we will discuss the results of the usability tests for CoachLab's dialogue editor. The case the participants received can be found in Appendix E.1, and the survey in Appendix E.2. The golden standard that was used to determine the precision and recall can be found in Appendix E.3, and all other results from the participants can be found in Appendices E.4 - E.10. In usability testing 5 is the 'magic' number. At a sample size of 5 participants most of the common problems will be identified [101]. We went with 7 participants to have a 90% percent certainty we'll find most of the common problems.

7.2.1 Precision & Recall

Precision and recall are measures to determine the accuracy of a test model when comparing to a golden standard. To measure the precision and recall we first had to determine what elements were required to reach the golden standard. Table 7 shows the elements that were required for a perfectly executed case.

	EM	CI	EM	CI	EM	CC	CC	EM	EM
Golden	ecoach_naam	coachee_naam	coachee_naam	coachee_leeftijd					
Standard	therapie_naam								
	therapie_duratie_weken								

Table 7: The elements of the golden standard

The columns show the nodes that were required, it shows the order in the flowchart as well. *'EM'* stands for E-coach Message, *'CI'* for Coachee Input, and *'CC'* for Coachee Choice. The rows beneath the node types depict the variables that were required in the input fields. Each each of these elements

counts as one required element for the golden standard. There are 9 nodes and 6 variables required, for a total of 15 elements. For each participant a similar table was created and the total amount of selected elements and the correctly chosen elements was counted. Those tables can be found in Appendices E.4 - E.10. To calculate the precision we divide the *correctly* identified elements by the *total* number of identified elements, while the recall is calculated by dividing the number of *correctly* identified elements by the number of elements in the *golden standard*.

$$precision = correct\ elements\ /\ total\ elements$$
$$recall = correct\ elements\ /\ golden\ standard$$

	Total Element	Correct Elements	Precision	Recall
Participant 1	16	15	94%	100%
Participant 2	13	11	85%	73%
Participant 3	15	15	100%	100%
Participant 4	15	14	93%	93%
Participant 5	15	15	100%	100%
Participant 6	15	15	100%	100%
Participant 7	17	13	76%	87%
Average	15.14	14	93%	93%

Table 8: Precision & Recall of the dialogue editor evaluation

As shown in Table 8 the evaluation resulted in very high percentages for both precision and recall. Both measures score 93%, which means their harmonic mean (the F1-score) is also 93%. This means the participants were accurate in their performance and on average executed the task near perfectly. When we take a look at where things went wrong the scores could have turned out even higher, since some of the mistakes seem accidental rather than conscious. An example of such a mistake is the second coachee input, which should be *'coachee_leeftijd'*, though two participants left the variable at *'coachee_naam'*. Even though they did add the second variable first. Another noticeable mistake is participant 1 who did everything perfect but somehow added a variable for the *'goodbye'*, though only added this variable to one of the messages that was meant for the goodbye. All in all it seems most participants were able to quickly solve the task they were presented with, even though they had no prior experience with the application.

7.2.2 System Usability Scale

After the participants were done with the tasks they were presented with a survey, the System Usability Scale (SUS). This survey consists of ten questions which will yield a final usability score. The score is calculated based on the formulas as defined by Brooke [100]. The score for each question is extracted from the likert-scale from 1-5, where 1 represents strongly disagree and 5 strongly agree. The scores for all participants are depicted in Table 9.

	1	2	3	4	5	6	7	8	9	10	Total Score
Participant 1	3	1	3	5	4	1	2	4	2	5	**45**
Participant 2	3	3	4	4	4	2	4	2	3	3	**60**
Participant 3	5	2	4	3	5	1	5	1	4	1	**87.5**
Participant 4	4	2	4	1	3	2	4	2	4	2	**75**
Participant 5	3	2	4	2	4	2	5	2	4	2	**75**
Participant 6	4	2	4	3	4	1	4	4	1	2	**62.5**
Participant 7	4	2	4	3	4	2	4	3	3	2	**67.5**
Average	3.71	2	3.86	3	4	1.57	4	2.57	3	2.43	**67.5**

Table 9: The SUS-scores of the dialogue editor evaluation

The results of the SUS show quite varying results. Participant 1 clearly scoring the dialogue editor the lowest. During the evaluation he mentioned several times he did not quite understand what node served what purpose. He was then prompted to read to the list of nodes again and in the end the conversation he produced was near-perfect (precision: 94%, recall: 100%). So, even though he did really well, he felt the tool requires a lot of foreknowledge to operate. A SUS-score of 67.5 can be called average, based on statistical analysis of hundreds of SUS-surveys [102].

7.3 Conclusion

To conclude we will try to interpret both SUS-scores, and precision and recall through observations made during the evaluation sessions. During the sessions the biggest thing that stood out was:

- **Learning threshold** - Most participants struggled at the start of the session, because they were not familiar with the system. It was clear that after they figured out what the purpose was of the different node types and how to add/insert variables they could quickly complete the task they were given. The easy nature of the application shows in the high precision and recall percentages.

  With these high performance percentages one could expect a high SUS-score as well, though the editor only scored 67.5 out of 100 on that scale. Looking at individual questions we see questions 4 and 10 score relatively low (after applying the formula [100]). Question 4 asked if the users felt they needed help with the tool, and question 10 asked if they felt they had to know a lot of the tool to use it. This is consistent with the observations that participants struggled in the beginning, and how they all started out playing with the tool, to familiarise themselves with it, first.

Some participants also had a little trouble to work out the way variables work. Participant 2 for example, he did not use them correctly at all. The nodes seem to be very clear to everyone, no one made mistakes in the node types and their order.

Another small note we got from participant 5, the usage of the *'Coachee Choice'* node was a little unclear due to the example of the tree structure in the case we presented. This tree depicts choice as a diamond shape, which is a common symbol for forking in modelling languages like BPMN. For our tool it would become to crammed to insert all choice options into one node, which is why each choice is a different node in CoachLab's dialogue editor. This does show us the need for clear instructions.

To conclude, the dialogue editor provides a powerful and relatively simple way to create conversations for an e-coach. However, to make this tool more accessible for authors it would be wise to implement some sort of tutorial in which the authors will walk through all elements of the editor. This will enable them to work with the tool much quicker and prevent trial and error from their side, since they know which tools are at their disposal and how to use them.

8   Conclusion

In this thesis we tried to design a framework based on existing methods and literature that enables authors of self-help books to create an autonomous e-coach, without technical knowledge. To address this we constructed the following research question:

RQ - *How can the creation of self-therapies for behaviour change be semi-automated with the help of (visual) tooling?*

The automation of the self-help therapies is done through the use of e-coaches. Those e-coaches use dialogue as their main communication modality and therefore conversations are the key ingredient to generating e-coaches. First a literature study was conducted to map the current field and to create an overview of existing applications and frameworks.

Due to the great variability in the different treatment domains, no practicable applications exist. Most studies that were found focused on one, or at most two, therapies and created e-coaches specifically for that. Some attempts were made at creating an ontology that could be the starting point of creating an e-coach, utilising reusable components that were valid across therapy domains. These attempts produced comprehensive models, though they were too complex and not usable without extensive therapeutic- and programming-knowledge.

Through analysis of self-help books we created interaction recipes for the most common exercise types within behavioural self-help therapies. By utilising these recipes an author can generate conversations based on a handful of characteristics they have to provide. Those conversations should be presented to the coachee at an appropriate time, based on scheduling or on violations of constraints. The scheduling and constraints are outside of the scope of this thesis, though they will be based on an existing model for e-coaches.

To prevent the author from being limited to only using the generated conversations a dialogue editor was created. This dialogue editor enables authors to quickly adjust generated conversations, or to create new conversations from scratch. This dialogue editor was evaluated and shows very promising results in terms of usability.

To conclude, this exploratory research provides a good starting point for the creation of an authoring tool that enables authors to semi-automatically generate e-coaches for therapies across all domains. We were able to make a generalising framework that enables authors to generate e-coaches. In this research the focus was specifically on designing the conversations and determining how a therapy is set up so we can generate these conversations based on input from the author in the form of variables. These conversations are based on the behaviour change model which was discussed in Section 4. This model is based on existing therapies and conversational techniques (see Section 2), and the coachings process as discussed in Section 3. As a behavioural strategy we use the negotiation algorithms within the exercises, which are based on an implementation by Beun et. al. and are utilised as a strategy to increase adherence [66].

The e-coaches created with CoachLab, could function as autonomous agents, though they can also be deployed as complementary to a self-help book. Using the dialogue editor the author can easily add references to book pages and by looking at the final layout of the e-coach the author can refer to elements of the e-coach within the book. This can help add interactivity and help-on-demand features to self-help books.

8.1 Limitations

Due to the complex nature of behavioural therapy there are some limitations to the research. The authoring tool as of now only supports the four exercise types for automatic generation of conversations. Other exercises will have to be modelled separately by the author. Though we do believe most exercises that do not need external tooling can be written in a form that is supported by our framework.

The success of the framework also depends on the applicability of the therapy. Therapies with relatively simple exercises (e.g. *monitor* miles walked, *do* relaxation exercises twice a day) will have the best chance of success because others might become too complex for authors to create. If the authors want more complex exercises, possibly utilising (external) tools, they might have to find someone to program that for them. An example would be an application where coachees have to draw what they are feeling. This is an exercise used in treatments for depression or anxiety, though too specific to include in a generalising application. This could be solved by using an *"instruction"* exercise and having the coachee draw on paper. However, authors might want this application within the e-coach to show coachees their previous drawings that were linked to the same emotion.

The negotiation algorithms also have some limitations. Our algorithms only negotiate on exercises that are based on metrics, like walking a *number* of miles or performing an instruction a *number* of times per day. Negotiation that is only based upon conversation or wants the motivation of the coachees is not yet possible.

Dialogues are automatically generated but they can also be adapted or created by the author. As of now there are some limitations as to how the conversations are to be structured. The structure always has to be a directed graph and the author has to make due with the existing node types. If in the future these node types will prove not to be sufficient, more will need to be added.

8.2 Future Work

In the future, the framework needs to be fully implemented to actually generate e-coaches. One part of this is the implementation of the scheduling and constraints mechanisms which will determine the actual behaviour of the e-coaches. This behaviour should determine when the e-coach should initiate a conversation or when to intervene. This scheduling and constraints model is based on

existing work, though has not been used by non-technical people. Introducing this system and familiarising the authors with the working of it, will be a challenge.

After this implementation several evaluations need to be held. First the usability of the whole of CoachLab needs to be tested, together with the user experience tested on the actual target audience. Besides the usability of CoachLab, case studies could be executed to validate the generated e-coaches on a therapeutic level. This validation can also be combined with comparisons between e-coaches generated with CoachLab and existing e-coaches which are specialised in one specific therapy.

As discussed in the evaluation of the dialogue editor there should be a tutorial to familiarise the authors with the dialogue editor, it is likely something of the same sort is also desirable for the tool in its entirety.

The framework utilises some behavioural strategies such as negotiation, though it could be extended and more could be added. An example would be a reward system. This could be implemented with the use of badges or ribbons. These would be earned by the coachee when predetermined targets have been met. Besides using rewards for predetermined targets, random rewards could also be interesting as described by Munson [103]. The randomness provides a surprise element which participants valued, because the predetermined ones became predictable and boring really quickly.

All-in-all the framework is by no means exhaustive but provides a good starting point for further research to polish and/or extend the authoring tool.

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A   Self-Help Books Analysis

	Tool/Conversational	Instructions		Monitoring	Questionnaire	Evaluation
		Once	Repetitive			
Week 1						
Starting position	X					
Alcohol Diary				X		
Test alcohol problem					X	
Knowledge test					X	
Advice	X					
Week 2						
(Dis-)advantages of alcohol	X					
Motivation questionnaire					X	
Setting a goal	X			X		
Alcohol Diary				X		X
Week 3						
Recognising high risk situations	X					
Inform your environment		X				
Learn to say 'No'	X					
Dealing with unpleasant thoughts		X				
Preventing Boredom		X				
Alcohol Diary				X		X
Week 4						
Slips and setbacks		X				
(Un-)helpful thoughts	X					
Alchohol Diary				X		X
Week 5						
Setting goals for the (near) future		X				
Emergency Plan		X				
Keeping the alcohol diary				X		X
Total	7	6	0	6	3	4

Table 10: Analysis of self-help book on alcohol addiction [84]

	Tool/Conversational	Instructions		Monitoring	Questionnaire	Evaluation
		Once	Repetitive			
Chapter 1						
Test stressors					X	
Test stress responses					X	
Chapter 2						
Physical Activity		X				
Test stresslevel inventorisation					X	
Chapter 3						
Radical experiences		X				
Test stress at work					X	
Test burn-out					X	
Chapter 4						
Test assertiveness					X	
Chapter 5						
Rationality test					X	
Test discovering irrational thoughts					X	
Chapter 6						
Test time spent on relaxation					X	
Relaxation at work			X			
Relaxation for sleep problems			X			
Total	0	2	2	0	9	0

Table 11: Analysis of self-help book on Stress [82]

	Tool/Conversational	Instructions		Monitoring	Questionnaire	Evaluation
		Once	Repetitive			
Week 1						
Sleeptest					X	
Sleepdiary				X		
Info on sleep environment		X				
Info on diet		X				
Info on sleep preparation		X				
Advice	X					
Week 2						
Info on bed usage		X				
Relaxation			X			
Test morning/evening person					X	
Test attitude and thoughts towards sleep					X	
Week 3						
Calculate sleep efficiency				X		X
Relaxation			X			
Reconsider test attitude and thoughts		X				
Week 4						
Calculate sleep efficiency				X		X
Relaxation			X			
Week 5						
Calculate sleep efficiency				X		X
Relaxation			X			
Discovering caveats in thoughts		X				
Minfulness		X				
Week 6						
Final Sleepbehaviour		X				
Quick Relaxation			X			
Reflection	X					
Evaluation		X				
Summary		X				
Total	2	10	5	4	3	3

Table 12: Analysis of self-help book on Insomnia [86]

B Flowcharts LylaCoach

General Introduction

Figure 19: Flowchart LylaCoach therapy introduction

Introduction exercise sleep diary

Figure 20: Flowchart LylaCoach sleepdiary introduction

Figure 21: Flowchart LylaCoach sleepdiary evaluation

ST = total Sleep Time
TIB = Time in Bed
SE = Sleep Efficiency
TTB = Time to bed
RT = Rise time

Regular flow
Circular flow
variable_name — User variables
variable_name — System variables
Bot text
Conversation option
Recurring option
Process

(sleepEfficiency) >= 60

In de introductie van de training heb ik verteld dat bedtijdbeperking deel zou uitmaken van de training, maar op basis van je slaapdagboek heb jij deze oefening niet nodig.

Van de tijd die je in bed ligt (gemiddeld *(TIB)* uur) slaap je al een groot deel, namelijk *(SE)*% (dat is *(ST)* uur). Het heeft daarom weinig zin om de tijd die je in bed doorbrengt te beperken. Ga wel door met de andere oefeningen. Volgende week kijken we of het nog steeds goed gaat.

Einde

(sleepEfficiency) < 60 && (evalAmount) == 0

Deze week beginnen we met de oefening bedtijdbeperking

(sleepEfficiency) < 60 && (evalAmount) > 0

Vandaag beginnen we opnieuw met bedtijdbeperking

Bij bedtijdbeperking beperk je je bedtijden tot het aantal uur dat je daadwerkelijk slaapt. Je ligt minder lang in bed. Omdat je minder tijd hebt om te slapen, word je vermoeider. Hierdoor kun je beter inslapen en word je minder vaak wakker 's nachts. Daarnaast verbind je je bed weer met slapen in plaats van wakker zijn.

Je voortgang houd ik bij via je slaapefficiëntie. Het doel van deze oefening is om de slaapefficiëntie omhoog te krijgen. Voordat we verder gaan, leg ik je uit wat slaapefficiëntie precies is.

Volgende

Bij bedtijdbeperking speelt de slaapefficiëntie een belangrijke rol. Doel is om je slaapefficiëntie op minimaal 60% te brengen. Je slaapt nu gemiddeld *(ST)* uur en je ligt *(TIB)* uur in bed. Je slaapefficiëntie is *(SE)*%. Gemiddeld lig je *(timeAwake)* uur wakker.

Door korter in bed te liggen gaat je slaapdruk omhoog. Hierdoor gebruik je relatief meer bedtijd om te slapen en kun je je slaapefficiëntie verhogen.

Wil je meer weten voor we verder gaan?

Wat moet ik precies doen?

Bij bedtijdbeperking pas je jouw bedtijden aan je gemiddelde slaaptijd aan. De bedtijd wordt nooit minder dan 5 uur. Zodra je minder wakker ligt en de slaapefficiëntie hoog genoeg is (60%), gaan we de bedtijden in kleine stapjes verlengen. Gebruik de tijd die je over hebt voor prettige en/of zinvolle activiteiten, zoals rustig ontbijten, douchen, lezen, wandelen, werken enzovoort.

Wil je meer weten voor we verder gaan?

Wat moet ik precies doen?

Bedtijdbeperking is een zware maar krachtige oefening. Je zult overdag meer drang hebben om te slapen. Dat is juist de bedoeling. In het begin hebben mensen overdag meestal meer klachten. Ik begrijp dat dit moeilijk is om vol te houden. Na ongeveer 3 weken treedt meestal verbetering op. We bekijken wekelijks je resultaten en afhankelijk van de slaapefficiëntie stellen we in overleg de bedtijden bij.

Wil je meer weten voor we verder gaan?

Ga verder

Dan stellen we nu samen je nieuwe bedtijden voor de komende week vast.

Ben je slaperig overdag? Heb je de neiging om in slaap te vallen bijvoorbeeld tijdens tv kijken, of na de lunch?

Ja, regelmatig

Ik adviseer je nooit minder dan 5 uur in bed te liggen, omdat ik wil dat je minimaal 5 uur slaapt. Omdat je nu slechts *(ST)* uur slaapt, stel ik voor om de bedtijden iets ruimer te nemen. Mijn voorstel is dat je totale tijd in bed *(proposalCoach)* uur wordt.

Ga je hier mee akkoord?

Nee, weinig of niet

Op basis van je slaapdagboek stel ik voor dat de totale tijd in bed *(proposalCoach)* uur wordt. Dit is gebaseerd op de hoeveelheid slaap die je nu krijgt.

Ga je hier mee akkoord?

Dan doe ik liever geen bedtijdbeperking

Jammer dat je wilt stoppen. Bedtijdbeperking is wel een goede oefening om je te helpen beter te slapen. Daarom doe ik nog 1 laatste voorstel: ga je akkoord met *(ultimateProposal)* uur in bed doorbrengen?

Nee, ik wil echt stoppen

Ja

Ik vind het jammer dat het niet gelukt is met bedtijdbeperking. Houd in ieder geval zoveel mogelijk vaste bedtijden aan. Hopelijk ga je door met de andere oefeningen en helpen die je met beter slapen.

Oké

(proposalCoach) < proposalMaximum

Ik lig liever iets langer in bed

Geef aan hoe lang je in bed wil liggen

(coacheeProposal)

Max 1x

Else

Je hebt voorgesteld dat je de komende week niet langer dan *(coacheeProposal)* uur in bed ligt. De oefening werkt beter als je je bedtijd zoveel mogelijk beperkt, tot ongeveer net zo lang als je vorige week sliep.

Daarom stel ik voor dat de totale tijd in bed *(proposalCoach) + 30* wordt. Ga je hiermee akkoord?

Oké

(proposalCoach) - (coacheeProposal) <= 30

Ik ga akkoord met jouw voorstel om niet langer dan *(coacheeProposal)* uur in bed te liggen.

Prima, we spreken dus af dat je de komende week niet langer dan *(agreedProposal)* uur in bed ligt.

Laten we nu afspreken welke bedtijden je de komende week gaat aanhouden. Ik stel voor dat je om *(TTB)* uur naar bed gaat en om *(RT)* opstaat. Dit baseer ik op hoe laat je afgelopen week doordeweeks opstond.

Ga je hier mee akkoord?

Ja

Nee ik wil andere tijden

Kies andere tijden om naar bed te gaan en op te staan

(TTB) + (RT)

Samenvattend is dit onze afspraak de komende week wordt: *(agreedProposal)* uur je totale bedtijd. Je gaat om *(TTB)* uur naar bed en staat om *(RT)* uur op.

Akkoord

ik wil toch graag andere tijden

Bedtijdbeperking is een zware oefening. Het kan goed dat je eerst vermoeider bent overdag. Als je volhoudt, zul je merken dat je vanzelf minder wakker gaat liggen in bed.

Over een week gaan we samen bekijken hoe het is gegaan. Als het nodig is passen we de bedtijden dan weer aan. Ik heb een afspraak gemaakt op *(nextConsultDate)* om *(nextConsultTime)* uur. Je kan de afspraak verzetten in de Agenda. Heel veel succes de komende week!

Akkoord

Figure 22: Flowchart LylaCoach sleep restriction introduction

Evaluation exercise sleepdiary

Legend:
- → Regular flow
- --→ Circular flow
- *{variable_name}* User variables
- *{variable_name}* System variables
- Bot text
- Conversation option
- ◇ Recurring option
- Process

Laten we kijken naar hoe de oefening bedtijdbeperking gaat. Hoe vind je zelf dat het gaat? Is het makkelijk of moeilijk om je aan de nieuwe bedtijden houden?

- Heel makkelijk
- Makkelijk
- Moeilijk
- Heel moeilijk

Fijn om te lezen!

Goed dat je het makkelijk vindt.

Wat jammer dat je het moeilijk vindt.

Vervelend om te horen vindt dat je het heel moeilijk vindt.

Je ligt gemiddeld *{TIB}* uur in bed, onze afspraak is *{agreedProposal}* uur. Je slaapt gemiddeld *{ST}* uur.

Je hebt je goed aan onze afspraak gehouden.

Ondanks dat je moeite hebt met de oefening, heb je wel goed aan onze afspraak gehouden.

Je vindt de oefening makkelijk. Toch lig je volgens je dagboek langer in bed dan we hadden afgesproken. Laten we samen uitzoeken waarom het je niet lukt. Hoe komt dit volgens jou?

Volgens je dagboek lig je langer in bed dan we hadden afgesproken. Laten we samen uitzoeken waarom het je niet lukt. Hoe komt dit volgens jou?

- Volgende
- Ik wil het hier niet over hebben.
- Mijn bedpartner heeft moeite met mijn nieuwe bedtijden
- Ik snap het nut van deze oefening niet
- Het lukt me niet

De oefening bedtijdbeperking verandert ook het avondritueel met je bedpartner. Je ging waarschijnlijk tegelijk naar bed, of een van jullie ging eerst. Je lag samen nog een tijdje te knuffelen in bed, las een boek of keek tv. Door je nieuwe bedtijden kan het zijn dat je partner nu juist alleen naar bed gaat en dat ongezellig vindt, of dat je partner wakker wordt als jij in bed komt liggen. Dat maakt het volhouden van je nieuwe bedtijden lastig.

Praat met je partner over je nieuwe avondritme. Leg hem/haar uit dat je dit uiteindelijk gaat helpen om beter te slapen. Als jij meer uitgerust bent, is dat ook fijner voor je partner.

Wat kun je doen om de overlast voor je bedpartner te verminderen? Zorg dat de weg van je slaapkamerdeur naar je bed vrij is. Of slaap allebei tijdelijk onder een 1-persoons dekbed. Wellicht heeft je partner zelf nog goede ideeën.

Zijn er nog andere obstakels?

Door minder lang in bed te liggen slaap je minder en wordt je slaapdruk verhoogd. Dit betekent dat je drang om te gaan slapen hoger wordt, waardoor je beter kunt inslapen en doorslapen. Gebruik de tijd die je over hebt om lichamelijk en geestelijk tot rust te komen. Dan heb je overdag vaak minder last van het korter in bed liggen.

Als je het grootste gedeelte van de tijd in bed weer slaapt, ga je langzaam je bedtijden uitbreiden. Uiteindelijk lig je niet alleen minder vaak wakker, je slaapt ook meer.

Hopelijk begrijp je nu beter waarom deze oefening zo belangrijk is. Je kan altijd meer uitleg lezen, ga naar menu > Oefeningen > Bedtijdbeperking.

Zijn er nog andere obstakels?

Het kan helpen om jezelf te belonen als je deze oefening goed doet. Laten we samen een beloning verzinnen die je jezelf geeft als je een week lang op de juiste tijd naar bed gaat.

Waarmee wil je jezelf belonen? Kies iets uit onderstaande voorbeelden, of vul zelf iets in.

Voorbeelden: naar concert of film gaan, iets nieuws kopen voor in je huis of tuin, jezelf verwennen met iets lekkers, nieuwe kleding kopen, uit eten gaan.

◇ *{reward}*

Zijn er nog andere obstakels?

- Nee, ga verder

Je slaapt al een groot deel van de tijd dat je in bed ligt. Nu gaan we proberen je totale slaapuren iets te verhogen zonder langer wakker te liggen. We doen dit met kleine stapjes, komende week mag je een kwartier langer in bed liggen.

Je ligt nog lang wakker in bed. Het beste is als je je nog een week aan deze tijden kunt houden. Waarschijnlijk bouw je nu moeheid op, waardoor je binnenkort iets langer gaat slapen. Hou vol!

Je hebt niet zo goed geslapen afgelopen week, ik begrijp dat dit een hele lastige oefening is. Probeer echt om je komende week aan de afspraak te houden. Ik stel voor om dezelfde bedtijden af te spreken als vorige keer.

Je hebt je goed aan de tijden gehouden en je slaapefficiëntie is niet slecht. Door nog een week dezelfde tijden aan te houden, kan het nog beter gaan.

Je slaapefficiëntie is niet slecht, maar je hebt je niet heel goed aan de afspraak gehouden. Ik stel voor dat je komende week de oefening wel goed doet. Houd dezelfde tijden als de vorige keer aan.

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We spreken dus af dat je de komende week niet langer dan *{TIB}* uur in bed ligt.

Ik vind dat we een goede afspraak hebben gemaakt. Over een week zullen we weer samen bespreken hoe het gaat en zo nodig de bedtijden bijstellen. De nieuwe afspraak staat op: *{nextConsultDate}* om *{nextConsultTime}*. Heel veel succes komende week. Het gaat je lukken!

if afgerond =
voldoende

if afgerond =
onvoldoende

Je hebt het SleepCare programma
tot een goed einde gebracht. Ik
hoop dat het je bevallen is.
Binnenkort krijg je een e-mail met
de afrondende vragenlijsten. Tot
ziens!

Het officiële SleepCare
programma is afgelopen. Mocht je
je slaap nog op een andere manier
willen verbeteren, dan kun je
contact opnemen met je huisarts,
een slaappsycholoog of
slaapcentrum. Binnenkort krijg je
een e-mail met de afrondende
vragenlijsten. Tot ziens!

Figure 24: Flowchart LylaCoach closure

C Negotiation Algorithms

For clarity, in all algorithms we use the following abbreviations:

- sp = starting proposal

- cp = coachee proposal

- np = new proposal

- avg = observed performance average

C.1 Monitoring Planning Negotiation

First, the **intended outcome**, should be selected (e.g. increase or decrease targeted behaviour). If it is clear whether a coachee should increase or decrease in a specific behaviour, perhaps within some boundary, the negotiation algorithm will negotiate a first **(temporary) goal** with the coachee. The author of the e-coach is able to tweak some settings of the algorithm such as: **starting proposal** (SP) (if omitted, coachee will make the first offer), **goal to strive for** based on therapeutic experience or research (if omitted the algorithm will aim to just increase/decrease, or aim for a **minimum/maximum**), and the **percentage** by which the e-coach will increase/decrease the offer made by the coachee. Algorithms 1 & 2 show the algorithms for planning, respectively with and without a starting proposal.

Algorithm 1 Planning Algorithm Monitoring (**With** a Starting Proposal)

1: **procedure** CREATING A COACHEE'S ACTION PLAN
2:     $temp\_goal \leftarrow sp$;
3:     **if** answer == "Agreed" **then**
4:         $break$;
5:     **else** $\triangleright$ No agreement
6:         $cp \leftarrow answer$; $\triangleright$ Check coachee's proposal
7:         **if** cp < min **then**
8:             $temp\_goal \leftarrow min$;
9:             $break$;
10:         **else if** cp > max **then**
11:             $temp\_goal \leftarrow max$;
12:             $break$;
13:         **else if** $(increase \,\&\&\, cp \geq sp) \,||\, (!increase \,\&\&\, cp \leq sp)$ **then**
14:             $temp\_goal \leftarrow cp$;
15:             $break$;
16:         **else** $\triangleright$ Try negotiating a slightly stricter value (np)
17:             **if** increase **then**
18:                 $np \leftarrow cp \times (1 + percentage)$
19:             **else**
20:                 $np \leftarrow cp \times (1 - percentage)$
21:             **if** answer == "Agreed" **then**
22:                 $temp\_goal \leftarrow np$;
23:                 $break$;
24:             **else**
25:                 $temp\_goal \leftarrow cp$;
26:                 $break$;

Algorithm 2 Planning Algorithm Monitoring (**Without** a Starting Proposal)

1: **procedure** CREATING A COACHEE ACTION PLAN
2:     $cp \leftarrow answer$;
3:     **if** cp < min **then**
4:         $temp\_goal \leftarrow min$;
5:         $break$;
6:     **else if** cp > max **then**
7:         $temp\_goal \leftarrow max$;
8:         $break$;
9:     **else** $\triangleright$ Accept coachee's proposal
10:         $temp\_goal \leftarrow cp$;

C.2   Monitoring Renegotiation

The renegotiation algorithm, as shown in Algorithm 3, is written for an intended outcome of increasing current behaviour. The algorithm can easily be flipped to determine the results if a decrease in behaviour is desirable. The algorithm bases its negotiation aim on the results achieved by the coachee in the past week. If the author specified a strive goal there are 5 values where the average of the coachee can be classified in, as visualised in Figure 25. Two values lower than the striving goal, two values higher, and one exactly equalling the striving goal. Values x_1 and x_2 are aimed to be increased by the negotiation algorithm (see lines 5-12 in Algorithm 3) while values x_4 and x_5 cause an attempt for decreasing in the negotiation algorithm. If the average performance of the coachee equals the striving goal the goal for the next week will remain equal to the striving goal. The Negotiate() function performs a maximum of 2 rounds where they lower their offer after a dismissal by the coachee [66].
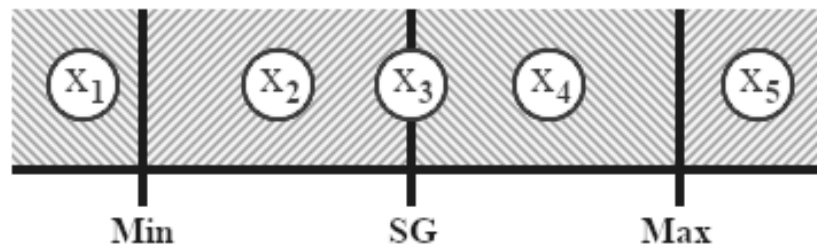
Figure 25: Renegotiation possibility space with strive goal

As shown in Figure 26, there are only three possible classifications for values when there is no strive goal. If no minimum or maximum is specified this is even reduced to just one. In this case the negotiation algorithm will just try to increase the goal of the coachee (within the min/max boundaries, if specified). The algorithm (Algorithm 4 also slightly changes since there is no need to specify the 5 possibilities we encountered in the previous scenario. If the average of the coachee is less than the minimum, the minimum will be used as a starting point for the negotiation, if it is above the maximum the maximum will be set as the goal, and if it is in between the algorithm will use the specified percentage to negotiate. A maximum of two negotiation rounds is maintained to prevent exhaustion and resentment from the coachee. The second iteration the coach will make a slightly more lenient offer than the first iteration.

Figure 26: Renegotiation possibility space without strive goal

---

Algorithm 3 Renegotiation Monitoring (**With** strive goal)

1: **procedure** RENEGOTIATION DURING MONITORING EVALUATION
2:     $avg \leftarrow system\_calculation$
3:     **if** $avg == sg$ **then**
4:         break;
5:     **else if** $avg < sg$ **then**   ▷ If $avg < sg$ try **increasing** towards sg
6:         **if** $avg < min$ **then**
7:             $temp\_goal \leftarrow min$
8:         **else**
9:             $temp\_goal \leftarrow avg$
10:         **for** $(i = 1; i \leq 2; i++)$ **do**   ▷ Negotiate for 2 rounds
11:             Negotiate($temp\_goal, i, TRUE$)
12:         break;
13:     **else**   ▷ If $avg > sg$ try **decreasing** towards sg
14:         **if** $avg > max$ **then**
15:             $temp\_goal \leftarrow max$
16:         **else**
17:             $temp\_goal \leftarrow avg$
18:         **for** $(i = 1; i \leq 2; i++)$ **do**   ▷ Negotiate for 2 rounds
19:             Negotiate($temp\_goal, i, FALSE$)
20:         break;

21: **procedure** NEGOTIATE(j, i, incr)   ▷ i = negotiation round
22:   ▷ j = current goal
23:     **if** incr **then**
24:         $temp\_goal \leftarrow temp\_goal \times (1 + percentage/i)$
25:     **else**
26:         $temp\_goal \leftarrow temp\_goal \times (1 - percentage/i)$

Algorithm 4 Renegotiation Monitoring (**Without** strive goal)

1: **procedure** Renegotiation during Monitoring Evaluation
2:    $avg \leftarrow system\_calculation$
3:    **if** $avg < min$ **then**
4:        $temp\_goal \leftarrow min$
5:        **for** $(i = 1; i \leq 2; i{+}{+})$ **do**   ▷ Negotiate for 2 rounds
6:            Negotiate($temp\_goal, i, TRUE$)
7:        break;
8:    **else if** $avg < max$ **then**
9:        $temp\_goal \leftarrow avg$
10:        **for** $(i = 1; i \leq 2; i{+}{+})$ **do**   ▷ Negotiate for 2 rounds
11:            Negotiate($temp\_goal, i, TRUE$)
12:        break;
13:    **else**
14:        $temp\_goal \leftarrow max$
15:        break;

16: **procedure** Negotiate(j, i, incr)   ▷ i = negotiation round
17:   ▷ j = current goal
18:    **if** incr **then**
19:        $temp\_goal \leftarrow temp\_goal \times (1 + percentage/i)$
20:    **else**
21:        $temp\_goal \leftarrow temp\_goal \times (1 - percentage/i)$

C.3 Instructions Planning Negotiation

The instructions exercise is relatively less complicated to model, than the previous one. The negotiation part only concerns how many days a week the exercise is executed. The default value will be 7, since most exercises are best performed each day of the week. This is substantiated by several studies on habit formation showing repetition being the key to forming new habits [92, 93]. Because of the importance of repetition and the fact that most exercises lose their point if not performed regularly, the minimum is set at three times a week. Apart from that the algorithm works the same as for the monitoring exercise, there are just less variables to tweak (e.g. the intended outcome is never aimed to decrease, the striving goal is always seven,and there is no percentage the e-coach rather just tries to increase the frequency by one day). This is only asked once to prevent the e-coach from seeming like a wiseacre.

Algorithm 5 Planning Algorithm Instructions

1: **procedure** CREATING A COACHEE ACTION PLAN
2:     $temp\_goal \leftarrow sp$
3:     **if** answer == "Akkoord" **then**
4:         break;
5:     **else**
6:         $cp \leftarrow answer$;
7:         **if** cp < min **then**
8:             $Negotiate(min)$;
9:             $break$;
10:         **else if** cp > 7 **then**
11:             $temp\_goal \leftarrow max$;
12:             $break$;
13:         **else**   ▷ Try to increase the goal by 1
14:             $Negotiate(cp)$;

15: **procedure** NEGOTIATE(cp)   ▷ Make coachee a new proposal
16:     $np \leftarrow cp + 1$
17:     **if** answer == "Akkoord" **then**
18:         $temp\_goal = np$
19:         $break$;
20:     **else**
21:         $temp\_goal = cp$
22:         $break$;

C.4 Instructions Renegotiation

Algorithm 6 Renegotiation Instruction

1: **procedure** RENEGOTIATION DURING INSTRUCTION EVALUATION
2:   $avg \leftarrow system\_calculation$
3:   **if** $avg < min$ **then**
4:    $temp\_goal \leftarrow min$
5:    **for** $(i = 1; i \leq 2; i++)$ **do** $\triangleright$ Negotiate for 2 rounds
6:     Negotiate$(temp\_goal, i)$
7:    break;
8:   **else if** $avg < max$ **then**
9:    $temp\_goal \leftarrow avg$
10:    **for** $(i = 1; i \leq 2; i++)$ **do** $\triangleright$ Negotiate for 2 rounds
11:     Negotiate$(temp\_goal, i)$
12:    break;
13:   **else**
14:    $temp\_goal \leftarrow max$
15:    break;

16: **procedure** NEGOTIATE(j, i) $\triangleright$ i = negotiation round
17:                 $\triangleright$ j = current goal
18:   $temp\_goal \leftarrow temp\_goal + (3 - i)$

D Interaction Recipes

D.1 Introduction

Hello, my name is {name_ecoach}. I'll be assisting you with {name_therapy}. This therapy will take {duration_therapy} weeks and consists of several exercises. Some are simple, other might take some more effort. Before I'll explain the exercises I'd like to know a little bit more about you. What is your name?

coachee_name

Hi {coachee_name}! To help you better, I'll need your age as well. How old are you?

coachee_age

Thankyou for the information. You can always adjust your details in the menu. First I'd like to clarify for whom this therapy is meant. {"This therapy is meant for:" target_audience}. {"And the goal of the therapy is to:" goal_therapy}. Do you recognize yourself in this target audience and do you want to achieve this goal with me, let's continue.

Continue

Lastly it's important to be paint a picture for yourself that's as realistic as possible. Don't expect miracles within a week. I'll be supporting you during your behaviour change, but you'll have to do the hard work 😊.

I will!

Alright then. Now let's have a look at the exercises we'll be doing, to give you a better image of what the therapy is going to look like. By clicking on the exercises you'll get more info.

Exercise 1   ....   Exercise n

Below I've specified the most frequently asked questions to address your concerns if you have any. If not, good luck!

FAQ 1   ....   FAQ n

Start!

D.2 Exercise Introduction
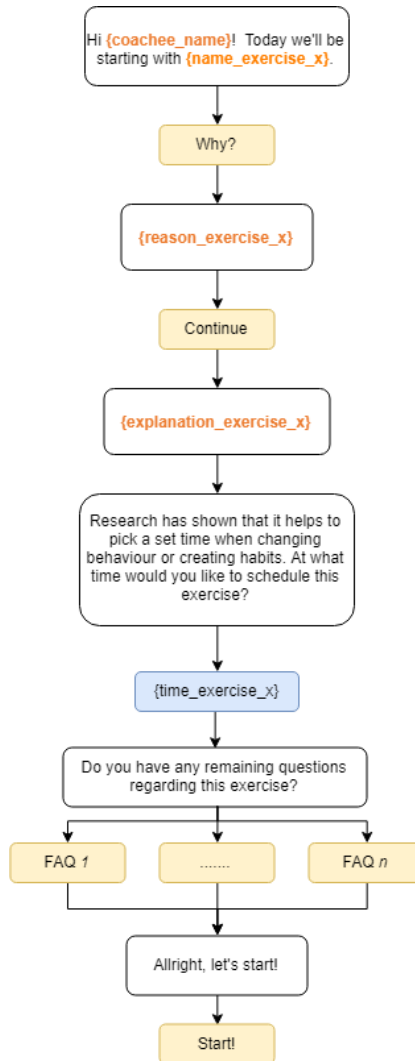
D.3 Exercise Evaluation

D.4   Monitoring Planning

To keep track of your progress I first would like
to create an action plan with you. This helps to
give you a better overview and gives you a goal
to strive for.

Negotiation Algorithm

Okay, that seems like a great starting
point. You can track your progress by
selecting the exercise in the menu and fill
in your values.

To summarise, this week you'll try to
{description_metric_verb*} {temp_goal}
{description_metric_noun*}

Agreed

Great! Good luck the next week. Do
remember that it won't always be
easy, but eventually you will benefit
from seeing it through!

Start!

* Example: keeping track of smoked cigarettes is the exercise.
    {description_metric_verb} = "smoke"
    {description_metric_noun} = "cigarettes"

This will yield the following sentence:
"This week you'll try to **smoke** {x} **cigarettes**.

D.5 Instructions Planning

To keep track of your progress I first would like
to create an action plan with you. This helps to
give you a better overview and gives you a goal
to strive for.

↓

Negotiation Algorithm

↓

Okay, that seems like a great starting
point. You can track your progress by
selecting the exercise in the menu and
selecting you did the exercise

↓

To summarise, this week you'll try to do
this exercise {temp_goal} times a week.

↓

Agreed

↓

Great! Good luck the next week. Do
remember that it won't always be
easy, but eventually you will benefit
from seeing it through!

↓

Start!

D.6 Negotiation Algorithm

*[1] Example: keeping track of smoked cigarettes is the exercise.
{description_metric_verb} = "smoking"
{description_metric_noun} = "cigarettes"

This will yield the following sentence:
"I would like to propose you start with **smoking** {x} **cigarettes**."

*[2] {np} = negotiation percentage

I would like to propose you start with
{description_metric_verb}[1]
{start_proposal (sp)}
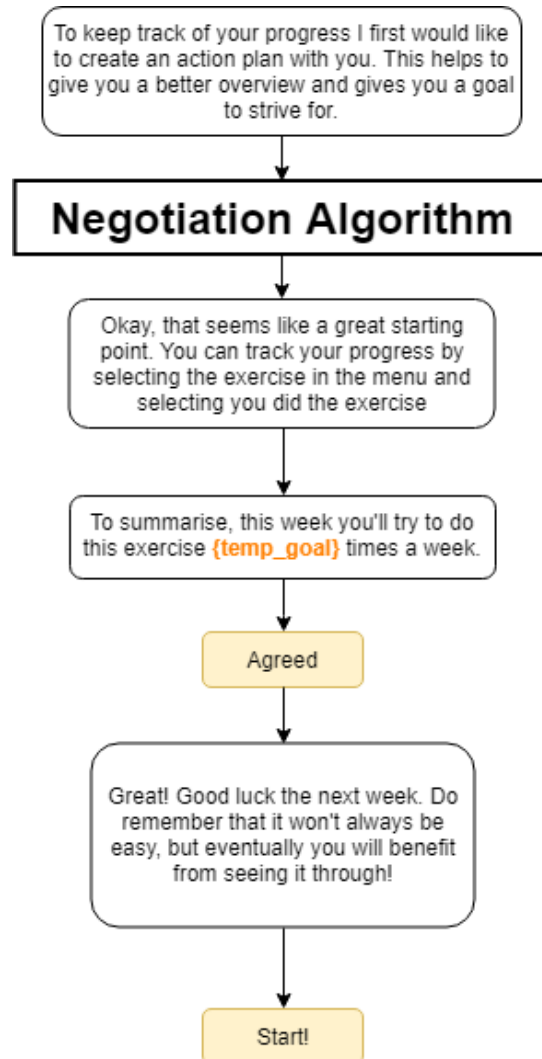**{description_metric_noun}**.

{coachee_proposal}
(cp)

Agreed

if **{cp}** < **{min}**

if **{cp}** > **{max}**

if **{cp}** > **{sp}**

else

I'm sorry but it's not responsible to go for a value this low. Are you okay to start with **{min}**?

I'm sorry but it's not responsible to go for a value this high. Are you okay to start with **{max}**?

How about going for
{cp} * (1+**{np}**[2])?

No

Yes

No

Yes

No

Yes

I'm sorry, but then there is nothing I can do for you.

{temp_goal} = **{min}**

I'm sorry, but then there is nothing I can do for you.

{temp_goal} = **{max}**

{temp_goal} = **{cp}**

{temp_goal} = **{cp}** * (1+**{np}**)

{temp_goal} = **{sp}**

Okay, so your goal for this week is:**{temp_goal}**.
Good luck with the exercise, I have scheduled the next evaluation on **{next_eval_date}** at **{next_eval_time}**.

D.7   Evaluation Algorithm

```mermaid
flowchart TD
```

if {feeling} == 0 && {agreement} → I see you indeed failed to meet your goal. Do you feel there is a reason?

if {feeling} == 0 && not{agreement} → I don't think you did that bad at all. Why did you feel you performed poorly this week?

if {feeling} == 1 && {agreement} → I do think you can do better than you showed this week. Do you feel there is a reason for this?

if {feeling} == 1 && not{agreement} → You said you had a hard time, but you did meet your target. Way to go! Why did you feel it didn't go so well?

if {feeling} == 2 && {agreement} → You're doing fine. Keep going!

if {feeling} == 2 && not{agreement} → You said it went pretty well, though the results are lacking. Did you forget to submit or is there another reason?

if {feeling} == 3 && {agreement} → It's going great! Keep doing what you're doing!

if {feeling} == 3 && not{agreement} → You said you had no troubles, but you didn't meet your target. Is there a reason for that?

- I felt the time didn't suit my schedule. → Okay, we'll set another time then. → {time_exercise_x} → I've set {time_exercise_x} as the new time for this exercise. Do you want to keep the same goal for next week? → Yes / No

- I don't really have a reason → Okay, no problem. We're just gonna try again this week! Do you want to keep the same goal? → Yes / No

- {reason_for_bad_results} → I'm sorry to hear that. I'd advise you to try and remove (or at least reduce) the things that hinder you when performing this exercise. Do you want to keep the same goal this week? → Yes / No

Renegotiation

End

E Evaluation

E.1 Case

Casus 1-1 Ontwerpen van gesprekken in CoachLab

Context
We testen hier een onderdeel van een systeem dat bedoeld is voor het maken van zogenaamde elektronische coaches (e-coaches). Het systeem, genaamd CoachLab, is een tool waarmee auteurs van zelfhulpboeken een eigen e-coach kunnen ontwikkelen. In zelfhulpboeken komen dikwijls oefeningen voor die de lezer van het boek moet uitvoeren. De e-coach is bedoeld als digitale versie van een echte coach die de oefeningen in het zelfhulpboek ondersteunt.

Het onderdeel dat we hier testen is het ontwerpen van gesprekken. In de gesprekken komen variabelen voor die naar wens aangepast kunnen worden door de auteur (denk aan: naam gebruiker, leeftijd gebruiker, naam oefening, etc..). Variabelen hebben een naam en een waarde. In deze opdracht ga je een eenvoudige dialoog maken met aanpassing van een aantal variabelen.

Nog een belangrijk onderscheid is het verschil in gebruikers. Er is de gebruiker van de uiteindelijke e-coach, vanaf nu: *coachee*. En er is de gebruiker van de dialoog-editor, vanaf nu: *auteur*.

Lees eerst de hele opdracht goed door voordat je begint aan de verschillende stappen.

Context Dialoog-editor
Voor je zie je de zogeheten dialoog-editor. Deze editor zal worden gebruikt om dialogen aan te passen en te creëren in CoachLab. De opdracht zal zich in dit scherm afspelen. Een gesprek in de dialoog-editor komt er uit te zien als een boomstructuur (zie voorbeeld Figuur 1 hieronder).
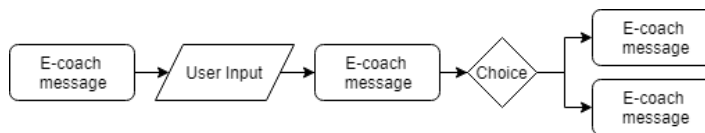
Figuur 1. Simpel voorbeeld van een boomstructuur.

Zo'n *boom* bevat *knopen* (de gespreksonderdelen) en *verbindingen*. Een *verbinding* betekent simpelweg een pad van 1 gespreksonderdeel naar de volgende. Er zijn 5 verschillende soorten *knopen*:

- **E-coach bericht** – Een simpel tekstbericht van de e-coach naar de *coachee*, dit bericht kan wel gebruik maken van variabelen die het systeem kent (zoals de naam van de *coachee*, de naam van de e-coach, beschrijving van een oefening, etc..).
- **Keuze** – Een keuze voor de *coachee*, die bepaalt welk pad in de boom wordt doorlopen.
- ***Coachee* input** – Een *coachee* moet soms een waarde in kunnen vullen (dit kan zowel een getal als tekst zijn), en deze waarde moet worden toegekend aan een variabele zodat deze later hergebruikt kan worden. (Voorbeelden zijn: de naam, leeftijd, of hobby's van een *coachee*)
- **Waarde variabele instellen** – Representeert het instellen van een bepaalde waarde voor een variabele **door het systeem** (een bepaalde keuze kan iemands waarde voor 'zelfstandigheid' verhogen).
- **Vertakking** – Een vertakking wordt gebruikt voor het splitsen in de boom op basis van een bepaalde waarde van een variabele (iemand die laag scoort voor 'zelfstandigheid' moet misschien een motiverender gesprek krijgen dan iemand die daar hoog voor scoort).

Opdracht:

In deze opdracht ga je een introductiegesprek maken. Je neemt de rol aan als auteur van het zelfhulpboek.De opdrachten moeten worden gelezen vanuit het perspectief van de e-coach, die een *coachee* gaat begeleiden met oefeningen in een therapie.

Je hebt naast de dialoog-editor een aantal variabelen tot je beschikking die al in het systeem staan:

Variabele Naam	Variabele Waarde
ecoach_naam	Gerbert de Slaapcoach
afsluiting	Bedankt voor je deelname, tot ziens!
therapie_naam	slaaptherapie
oefening1_coachee_gevoel	matig
therapie_duratie_weken	6

Zoals je ziet in de tabel is de waarde van sommige variabelen tekst en andere een getal. In de dialoog-editor kan je een variabele naam toevoegen in een **E-coach Bericht**. In de uiteindelijke gesprekken zal daar dan de waarde van zo'n variabele weer worden gegeven.

Nu begint het ontwerpen van het gesprek. Lees gerust de tekst hierboven nog eens door als je twijfelt. Kijk vooral goed naar welke *knoop* (gespreksonderdeel), waarvoor dient, en waar je een variabele zou kunnen gebruiken. Succes!

- Begin als e-coach met een gesprek door jezelf voor te stellen, vertel hoe je heet, bij welke therapie je de *coachee* gaat helpen en hoe lang deze duurt. Doe dit aan de hand van de variabelen die hiervoor beschikbaar zijn.

- Vraag de *coachee* nu naar zijn naam

- Geef de *coachee* de mogelijkheid om zijn naam in te voeren en sla deze op als variabele met de naam: 'coachee_naam'

- Begroet nu de *coachee* bij zijn naam en vraag hem naar zijn leeftijd.

- Geef de *coachee* de mogelijkheid om zijn leeftijd in te voeren en sla deze op als variabele met de naam: 'coachee_leeftijd'

- Vertel hem dat je het fijn vindt dat hij deze uitdaging met je aan wil gaan en vraag vervolgens of hij er tegenop ziet.

- Geef de *coachee* twee keuzes in het gesprek, of hij er wel of niet tegenop ziet. Sluit vervolgens, afhankelijk van de keuze, af met een passend bericht.

Vul, als als je denkt klaar te zijn, nog de vragen in van de survey. Dit duurt ongeveer 5 minuten.

E.2   SUS Survey

Survey

1. Ik zou deze tool, voor het bereiken van een vergelijkbaar doel, ook gebruiken.

    Oneens ☐   ☐   ☐   ☐   ☐   Eens

2. Ik vond de tool onnodig complex.

    Oneens ☐   ☐   ☐   ☐   ☐   Eens

3. Ik vond de tool makkelijk te gebruiken.

    Oneens ☐   ☐   ☐   ☐   ☐   Eens

4. Ik heb hulp nodig om deze tool goed te gebruiken.

    Oneens ☐   ☐   ☐   ☐   ☐   Eens

5. De verschillende stappen van de tool pasten goed bij elkaar.

    Oneens ☐   ☐   ☐   ☐   ☐   Eens

6. De verschillende onderdelen van de tool hingen niet goed met elkaar samen.

    Oneens ☐   ☐   ☐   ☐   ☐   Eens

7. Ik denk dat de meeste mensen deze tool snel kunnen gebruiken.

    Oneens ☐   ☐   ☐   ☐   ☐   Eens

8. Ik vond de tool onhandig in gebruik.

    Oneens ☐   ☐   ☐   ☐   ☐   Eens

9. Ik voelde me zeker van mijn zaak tijdens het gebruik van de tool.

    Oneens ☐   ☐   ☐   ☐   ☐   Eens

10. Ik moet veel van deze tool te weten komen voor ik hem effectief kan gebruiken.

    Oneens ☐   ☐   ☐   ☐   ☐   Eens

Figure 27: The questions of the survey

E.3 Golden Standard

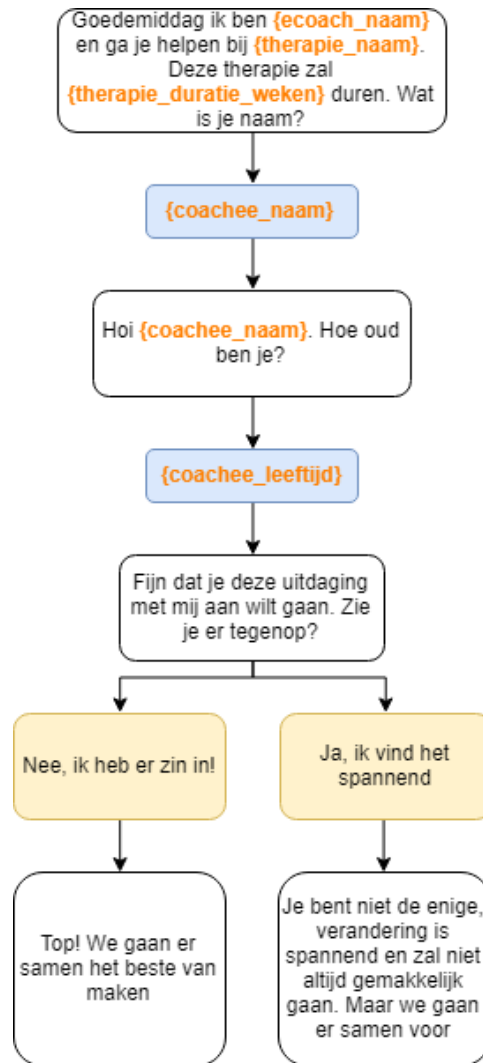
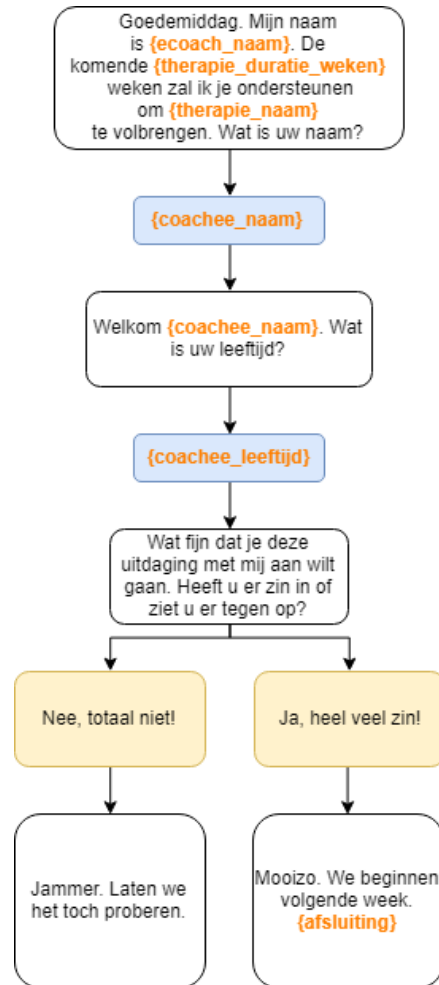Figure 28: Flowchart of the golden standard

E.4   Participant 1

Figure 29: Flowchart of the conversation created by participant 1

	EM	CI	EM	CI	EM	CC	CC	EM	EM
Participant 1	ecoach_naam	coachee_naam	coachee_naam	coachee_leeftijd					afsluiting
	therapie_naam								
	therapie_duratie_weken								

Figure 30: Table showing the elements used by participant 1

E.5 Participant 2

Figure 31: Flowchart of the conversation created by participant 2

	EM	CI	EM	CI	EM	CC	CC	EM	EM
Participant 2	coachee_naam	coachee_naam	coachee_leeftijd	coachee_leeftijd					

Figure 32: Table showing the elements used by participant 2

E.6 Participant 3
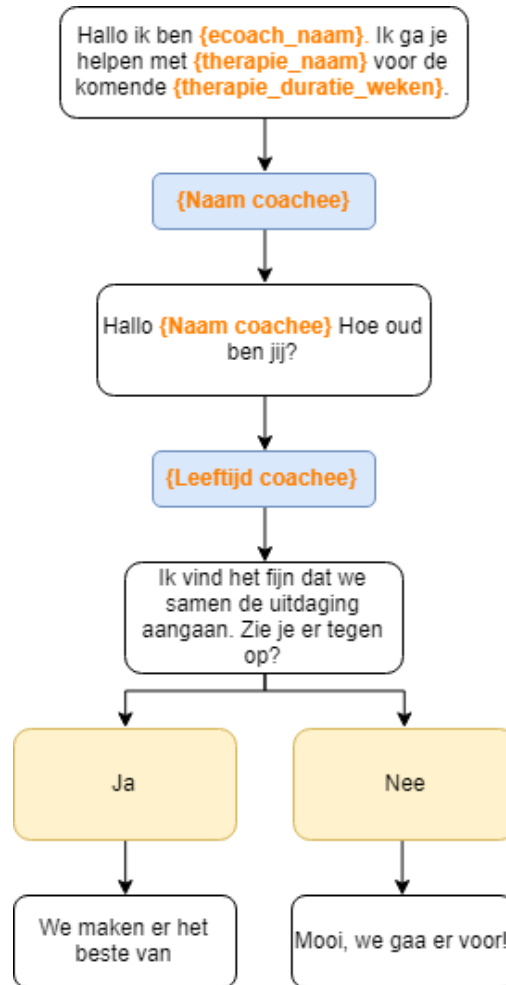
Figure 33: Flowchart of the conversation created by participant 3

	EM	CI	EM	CI	EM	CC	CC	EM	EM
Participant 3	ecoach_naam	coachee_naam	coachee_naam	coachee_leeftijd					
	therapie_naam								
	therapie_duratie_weken								

Figure 34: Table showing the elements used by participant 3

E.7 Participant 4
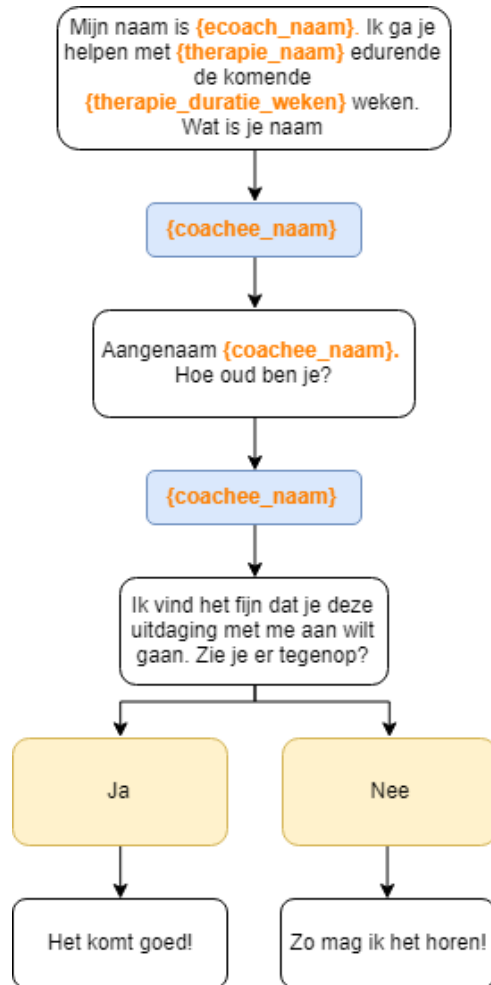
Figure 35: Flowchart of the conversation created by participant 4

	EM	CI	EM	CI	EM	CC	CC	EM	EM
Participant 4	ecoach_naam	coachee_naam	coachee_naam	coachee_naam					
	therapie_naam								
	therapie_duratie_weken								

Figure 36: Table showing the elements used by participant 4

E.8   Participant 5
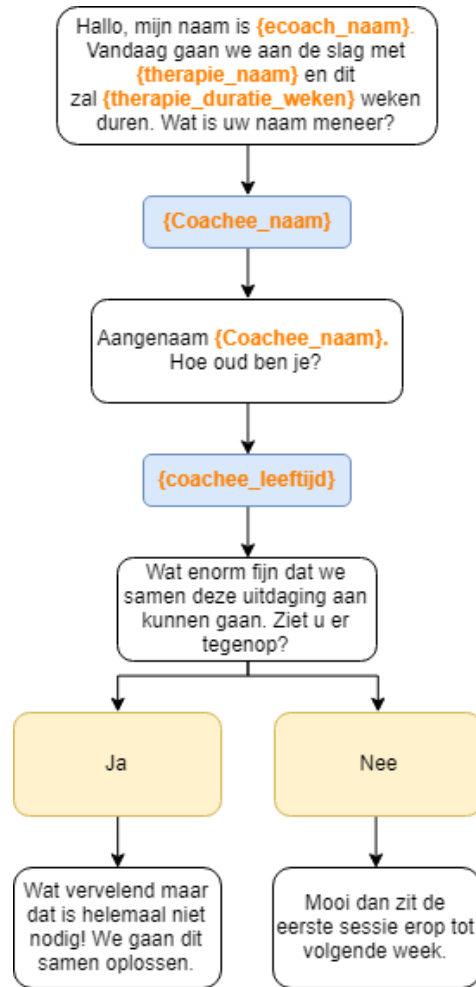
Figure 37: Flowchart of the conversation created by participant 5

	EM	CI	EM	CI	EM	CC	CC	EM	EM
Participant 5	ecoach_naam	coachee_naam	coachee_naam	coachee_leeftijd					
	therapie_naam								
	therapie_duratie_weken								

Figure 38: Table showing the elements used by participant 5

E.9 Participant 6
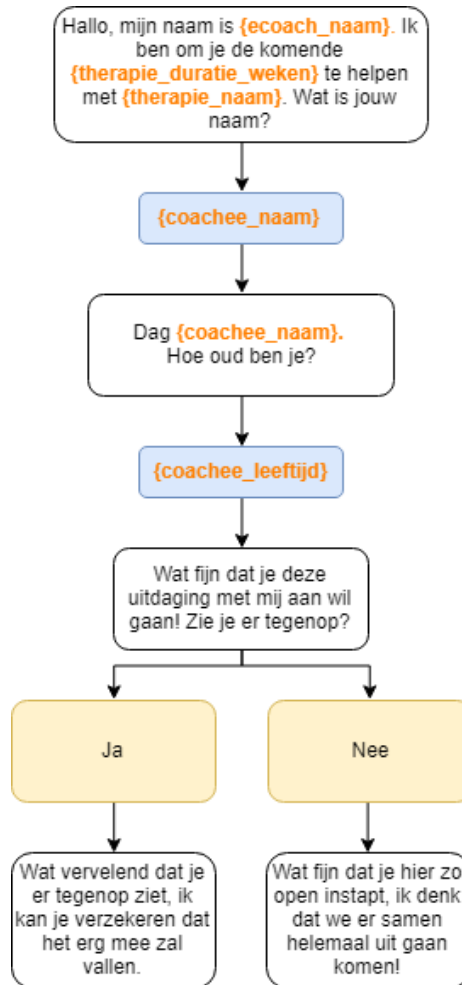
Figure 39: Flowchart of the conversation created by participant 6

	EM	CI	EM	CI	EM	CC	CC	EM	EM
Participant 6	ecoach_naam	coachee_naam	coachee_naam	coachee_leeftijd					
	therapie_naam								
	therapie_duratie_weken								

Figure 40: Table showing the elements used by participant 6

E.10 Participant 7
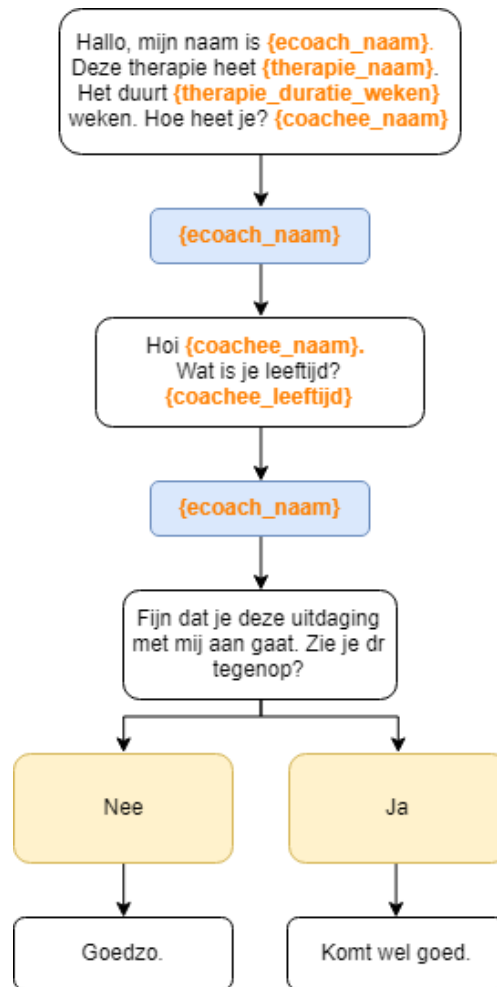
Figure 41: Flowchart of the conversation created by participant 7

	EM	CI	EM	CI	EM	CC	CC	EM	EM
	ecoach_naam	ecoach_naam	coachee_naam	ecoach_naam					
Participant 7	therapie_naam		coachee_leeftijd						
	therapie_duratie_weken								
	coachee_naam								

Figure 42: Table showing the elements used by participant 7