Working with a Virtual Health Coach

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ABSTRACT

Health campaigns offering carrot and stick approaches tend to have temporary success because they do not build a working relationship with the individual. Even sensor-enabled technology providing personalised and targeted support, often fails to deliver lasting behaviour change. In seeking answers, we have studied the literature on adherence to medical advice, which is on average around 50% whether delivered by a human or via technology. We propose the use of Virtual Coaches, artificially intelligent agent-based technology that uses a virtual human to provide education, motivation and choices via conversation-like interaction that overcomes health literacy barriers. The approach seeks to build a *working alliance* between the human and agent through negotiated goals, shared plans to reach the goals and a sense of rapport and caring. Recommendations for the design of conversations with virtual coaches are presented based on pilots with paediatric patients on the waiting list at a children's hospital.

CCS CONCEPTS

• **Computing methodologies** → Intelligent agent

KEYWORDS

Agent-based modelling, Intelligent agents, Simulation, Virtual reality, Working Alliance, Virtual Coaches

1 INTRODUCTION

In order to change unwanted habits and follow a new regime, individuals must be empowered, requiring a strong sense of control, self-efficacy, motivation and knowledge. However, in contrast to the situation of those in developing countries, the problems facing modern society and the Western world are, in general, not a lack of empowerment, choices or access to information and other resources. Healthy lifestyle and wellbeing information are readily available. A Google search will reveal a vast array of websites, pdfs, YouTube clips, workshops and campaigns to teach us safe practices and behaviours. Yet, endemic societal problems, such as obesity and mental health conditions, continue to rise indicating that access to resources and the freedom to choose what we do with them is not enough to change harmful behaviours. Perhaps the support and encouragement provided by eCoaching technology will be more successful in changing our poor behavioural choices? But, even if we are sent personalized reminders when we forget, rewarded when we do the right thing, offered tailored explanations when we don't understand, or warned when sensors detect our non-compliance, will that change human failure to follow the advice we are given, even when we *know* it is good for us?

With the intention of building eCoaches that deliver positive behaviour change and improved health outcomes, we have investigated the literature related to lack of adherence to medical advice; a significant problem identified at least since the 1970s. It is not surprising that better outcomes are associated with greater adherence, and vice versa. Studies report that regardless of condition, adherence averages around 50% for both technology and non-technology-mediated interventions, with adherence to cognitive behavioural therapy (CBT) particularly problematic [7]. Using the earlier more common term of compliance, Karoly [10] defines compliance as the "goodness of fit between a program of health/illness management designed primarily by a health professional and the program-specific behaviours enacted by a patient (or patients) and/or those individuals in a caretaking role" (p.12).

Researchers looking at the efficacy of eHealth communication strategies have focused on enablers (self-efficacy, knowledge and social support) and outcomes (emotional, behavioural, clinical and economic) of adherents. The adherence literature, however, points to the existence of a caring and trusting relationship between the patient and health provider as the key to improving adherence and health outcomes **[5]**. This relationship has been referred to as a therapeutic alliance, working alliance, therapeutic working alliance and helping alliance. The quality of the therapeutic alliance has been shown to be the most robust predictor of treatment success in psychotherapy treatment **[15]**. Furthermore, adherence has been found to increase when there is increased interaction and empathic dialogue [11].

The aim of this article is to look at how an eCoach can build a computer-human working alliance to encourage positive behaviour change through empathic and empowering interactive dialogues. To provide humanlike behaviours, we utilise Intelligent Virtual Agent (IVA) technology to design and deliver Virtual Coaches that are available 24/7 to play such a role. We use the term Virtual Coach to stress that the artificially intelligent agent-based technology provides a conversational and embodied humanlike coach.

In this article, we first present possible potential benefits of virtual coaches for health and wellbeing. After a short case study involving a paediatric population, we discuss our learnings from the case study concerning developing a working alliance. We conclude with current and future challenges for IVA technology.

2 VIRTUAL COACHES FOR HEALTH AND WELLBEING

To change behaviour, the Virtual Coach must be more than humanlike, as success rates for adherence to interventions mediated by humans are comparable to technology-mediated interventions [7]. The Virtual Coach must overcome barriers, build a working alliance, challenge attitudes and adapt to their trainee using behaviours similar to what we find in successful human coaches.

2.1 Overcoming barriers

A key goal of an embodied conversational agent is to overcome barriers due to low health and other forms of literacy that negatively impact on the efficacy and success of eHealth systems to provide information and interventions, and promote treatment adherence [3]. The familiar format of face-to-face conversation using a simplified and explicit method of interacting has been shown to achieve better health outcomes for patients with low computer, reading and health literacy skills, provide increased and tailored levels of engagement needed for repeated and ongoing adherence, and reduce confusion and misunderstandings [4]. Furthermore, researchers have found that computer-mediated interactions via a humanlike character can have advantages over human face-to-face interactions including increased accessibility, increased confidentiality and divulgation, tailored information, diminished variability, infinite patience and avoidance of righting reflex, expressing empathy, addressing low literacy, lowering attrition rates, allowing patient-physician concordance/matching and provide a working alliance [12]. Lisetti [12] seeks to gain these advantages by creating a personalized On-Demand VIrtual Counselor (ODVIC) to provide computer-delivery of Brief Motivational Interventions (BMIs) for behaviour change.

Particularly for stigmatised conditions, such as mental health, conversation with a relational agent can be less stressful and difficult than conversation with a human and provide a non-judgmental [8], and even fun, mentor or peer to encourage treatment adherence.

2.2 Improving Adherence

Virtual coaches need to develop a relationship with the human. A *relational agent* seeks to change the power model and assist human agency by providing the patient with a greater sense of control and self-efficacy. According to Bickmore, a leading IVA researcher in medical applications, "Relational agents are computational artifacts designed to build long-term socio-emotional relationships with users, including trust, rapport and therapeutic alliance, for the purpose of enhancing adherence to treatment" [4] p. 7).

To promote adherence, the Virtual Coach aims to build a therapeutic alliance with the human. A therapeutic alliance encompasses the degree to which the helper and client agree on the goals of the therapy and tasks to be performed, and the extent to which a bond between the helper and client is trusting and empathetic [8]. In layman's terms, there is agreement on the goal(s) and steps to achieve the goal(s) in a caring relationship.

A meta-analysis of adherence in 18 technology-mediated therapies for insomnia found adherence to be 52% on average [9]. One of the reported studies [2] had particularly focused on addressing the adherence problem, taking into consideration the importance of intrinsic and extrinsic motivations and the use of "three persuasive strategies that may influence motivation considerably in a positive manner: "alignment," (therapy, communication and ethical/trust levels); "adaptation, (information exchange, exercising)" and "motivational support" via verbal and non-verbal communication to deliver challenges, encouragement and confirmations". Horsch, Lancee, Beun, Neerincx and Brinkman [9] conducted 15 semi-structured interviews and six focus groups comprised of possible users (15), sleep experts (7) and lifestyle, relationship and career coaches (9) to explore barriers and solutions to adherence. Inconsistent with their actual behaviours, users believed they were adherent and that will-power was the key. In general, focus group participants did not like the idea of awarding points. Coach and users were negative about paying compliments and users only considered reminders to be useful if they remained in control of when to set them. Two types of people were identified: those who want explanations for why something should be done and those who want to "do" the activity and later think about gaining an understanding. A recurring theme was the need for strategies to enable the user to not feel they were the only one with the problem, with suggested solutions such as forums where individuals could share their stories.

2.3 Challenging Attitudes and Behaviours

While the ultimate goal of a Virtual Coach is to bring about and/or sustain behaviour change, a key element that can be seen as a precursor, is attitudinal and belief change. The importance of trainee attitude on training outcomes is consistent with the Kirkpatrick model of evaluating effectiveness of training [13]. To challenge current behaviours, trainee nurses interacted with virtual patient models to practice their patient communication and conflict resolution strategies [6].

A Virtual Coach might be used to educate and change attitudes in one group, such as family or peers, in order to deliver changes in behaviours and outcomes for another group in need of support. For example, by educating the population about mental health, those suffering from mental and other stigmatizing conditions, are more likely to seek help. We conducted an experiment with 245 participants to explore the use of ECAs versus videos with actors to deliver two strategies (Education and Contact) that have been found to be useful in changing stigmatizing attitudes towards mental health conditions. The

Education strategy (video and ECA versions) represented a doctor (Alice) who described the symptoms of Anorexia Nervosa (AN) and discussed the biological and environmental factors that contribute to development of AN. The Contact video and ECA represented an individual (Sarah) who had recovered from AN [17] who provided similar information in a less formal and more personal way. Both media (video and ECA) improved recognition of the symptoms of AN and produced significant changes in the belief that individuals with AN are responsible for their condition (known as volitional stigma) but not in more the traditional form of stigma that is measured through desire for social distance. We found gender differences for the Contact versus Education strategies, with significant reduction in volitional stigma in males, with no difference for females between the strategies. This indicates the possible importance of tailoring who the Virtual Coach represents and their role according to certain demographics.

2. 4 Knowing and Responding to the User

A successful coach or teacher knows what does or does not motivate their trainee to improve/ change and is able to adapt their behaviour accordingly. Data captured through sensors and extracted from other sources could make Virtual Coaches more aware of their user and enable them to support their trainee in meaningful ways. A review including 49 studies on the use of ECAs in clinical psychology [14], draws attention to the SimSensei project that uses an ECA to provide counselling to sufferers of post trauma stress disorder (PTSD). Using the Multisense software, the emotions of the patients are detected via language, facial expression and body posture to ensure that the Virtual Therapist is empathic and exhibits congruent and appropriate behaviours. Patients using this system have reported that they preferred the use of the ECA over a human as they felt the ECA was less judgemental than a human [8].

In addition to the use of sensor data to detect the user's current state, in our various studies we have collected data such as medical history, health literacy scores, change in quality of life (QoL) scores, treatments recommended by the system, adherence to treatment advice, dialogue interaction and choices, working alliance inventory scores, personality scores, Depression, Anxiety and Stress Scores (DASS21), users' knowledge of the conditions, and users' social networks. In the case study presented in the next section, patient history and adherence data feed into the next treatment plan (available fortnightly). Currently much of the data (e.g. health literacy and QoL) is captured via pre- and post-study surveys to measure efficacy of the treatment and technology, but could also be used to tailor interactions.

To replace incorrect beliefs with positive, helpful and accurate responses, Virtual Coaches will need a myriad of data such as psychological profiles and behaviour patterns to understand individual preferences and vulnerabilities. Getting to know the user and providing personalised responses will require real-time data acquisition and analysis and algorithms that allow the IVA to adapt appropriately.

3 eADVICE- Continence

Over the past 5 years, to address the problem of a 2 year public hospital waiting list, eADVICE (electronic Advice and Diagnosis Via the Internet following Computerised Evaluation)-continence was designed, and was pilot tested on children with incontinence while awaiting their specialist appointment. The eADVICE program facilitates the exchange of information between the child, their parents and specialist which is incorporated into evidence based treatment algorithms to enable assessment, diagnosis and individualised treatment advice which the program provides to patients and their families under the supervision of their General Practitioner (GP). A total of 157 patients have used one of the 5 pilot versions of eADVICE-continence. The initial pilot programs were text based with overall adherence rates of around 50%. Drawing on the work of Bickmore with relational agents with adults, we decided to add an IVA known as Dr Evie (eVirtual agent for Incontinence and Enuresis) into the program to improve adherence. Our general Virtual Coach architecture is shown in Figure 1. At the bottom we see the original eADVICE website and how it connects to the general architecture.

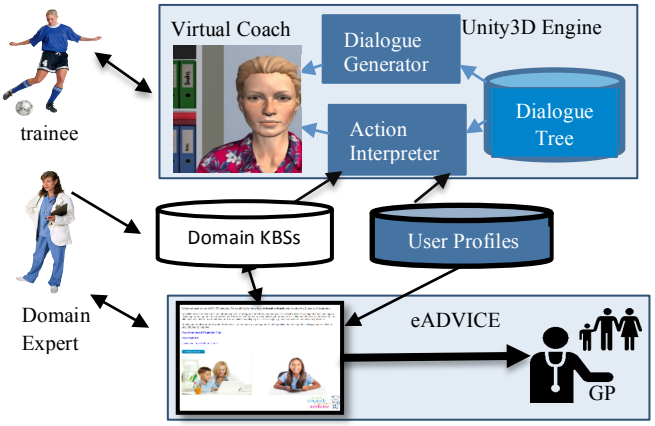

Fig 1: Virtual Coach Architecture, showing its integration with eADVICE.

Prior to adding Dr Evie the patient (trainee) would directly interact with the eADVICE program to enter their medical history and obtain one or more text based treatment plans. The plans would also be sent to their GP. We created Dr Evie, a female character with no discernible cultural background, suitable to the Australian multicultural society. We chose a female because female physicians are associated with empathic communication and relationship building [16 p.17]. Dr Evie (not shown) conveys a positive/smiling disposition and the text of her dialogue appears as speech bubbles accompanied by the audio recordings of the specialist's voice that is lip-synched with the character. The user is provided with options in response to the virtual doctor's questions and statements. We avoided TextToSpeech (TTS) because of its likely interference with sense of immersion and development of the therapeutic alliance.

Dr Evie greets families at the start of the eADVICE session and converses with them again after they have received their

recommended treatments. This was a compromise due to lack of funding, as we would have preferred for patients to interact with Dr Evie throughout the program to provide their medical history. Instead, text webpages are used to gather the medical history of the patient, data on fluid inputs and outputs and also whether the patient has followed the recommendations. Patient profile data are stored in a MySQL database and utilised by the rules in the eADVICE algorithm to provide six possible treatment recommendations. These rules were crafted by the specialist. A patient may receive one or more treatment recommendations. The recommended treatments are displayed to the patient and also sent to the patient's GP. To manage the conversation and Dr Evie's behaviour, we have created a Dialogue Generation and Action Interpreter in the Unity3D Game Engine with lip synching plugin. For evaluation purposes, statistics about usage of Dr Evie is captured in another database.

Based on our ability to recruit and retain participants and the feedback they provided, pilots 1-5 collectively showed that patients and families were interested to access eADVICE while awaiting their specialist appointment. Followup at six months with 74/79 Pilot 5 participants still on the waiting list, revealed the following outcomes for bedwetting: 22% dry, 33% improved, 33% same, 5% worse, 7% unknown and for daytime wetting: 54% dry, 19% improved, 12% same, 0% worse, 15% unknown. This response is far superior to spontaneous cure rates of 7% over six months.

Pilots 4 and 5 with Dr Evie, show that patients were willing to discuss their advised treatments with a virtual coach. The data show that after adding Dr Evie to eADVICE, adherence rates were 100% for Reduce caffeine, 97% for Fluid advice, 94% for Bowel Program, 72% for Timed voiding and 62% for Alarm training and 33% for Medication discussion, an average of 85% adherence if we exclude the outlying medication discussion results (dicussed in the next section). Prior to Dr Evie, parents reported overall adherence of around 50%, consistent with the average reported across the literature [7]. Thus, we found that children using pilot 4 and 5 engaged better with the program, were more adherent to the treatment advice given, and appeared to have better treatment outcomes compared with users of earlier versions of eADVICE without Dr Evie. As summarised by one family when asked what they liked about eAdvice, they responded: "*Dr Evie - good for the child to hear the advice from a non-family member. Computerised person appeals to the child. Info was presented very clearly, didn't leave us unclear about how to proceed. Dr Evie was encouraging, almost empathetic! It was good that someone pre-empted the likelihood that the program may not be followed completely/that well and that subsequent visits reinforced previous advice.*".

3.1 Building & Maintaining the Working Alliance

The previous quote identifies some key elements that contribute to the ability of the Virtual Coach to build a therapeutic working relationship that will lead to behaviour change and adherence to treatment advice. The possible *neutrality* of the Virtual Coach that is not a family member or in a coercive position of power and the preference for a *computerised person* is similar to reported preferences of PTSD patients for a virtual therapist over a human due to its perceived *non-judgemental* behaviour [8]. The desire to not be judged is perhaps captured in the words "the likelihood that the program may not be followed completely". These sentiments reveal a desire for a *forgiving* coach that *understand*s their strengths and weaknesses, consistent with their observation that Dr Evie was *encouraging* and *empathetic*. Of course, the message delivered is also important and the need for the message to be *clear*, *provide direction* and *reinforced previous advice* were identified.

We attribute these perceptions to the design and quality of the Dr Evie dialogues. The dialogues were designed based on the expertise of the medical specialist's team from decades of interactions with patients. Seven dialogues were created, one for each of the possible six treatments and a welcome dialogue. We analysed the design of our dialogues using verbal communication persuasive strategies to change a patient's behaviour or perspective such as Cialdini's 6 Principles of Influence: reciprocity, commitment/ consistency, social proof, authority, liking and scarcity. Our goal was to empower and support behaviour change through helping the patient choose their own strategies from suggestions offered rather than convince them to do what we said. Thus, we encouraged commitment and consistency, but avoided tactics such as "I'll do it if you do it" (reciprocity), "others [like you] are doing it" (social proof), "You should listen because my advice is based on expertise and years of experience/studies have shown" (authority); "I am your friend and want to help you" (liking); "Each time you don't follow the advice is a missed opportunity of a healthier life!" (scarcity). Instead our dialogue designs drew on the notion of a *working alliance* to ensure development of a *bond* and *agreement of goals and plans*.

Keeping in mind the importance of *empowerment* and allowing the user to make their own *informed choices*, we also found that utilising the above persuasive strategies can be effective for creating awareness about patient behaviour and realizing the discrepancy between their current actions and their desired goals. Related to achieving a working alliance, the desired goals and associated plans can be discussed, and even negotiated, with the virtual coach.

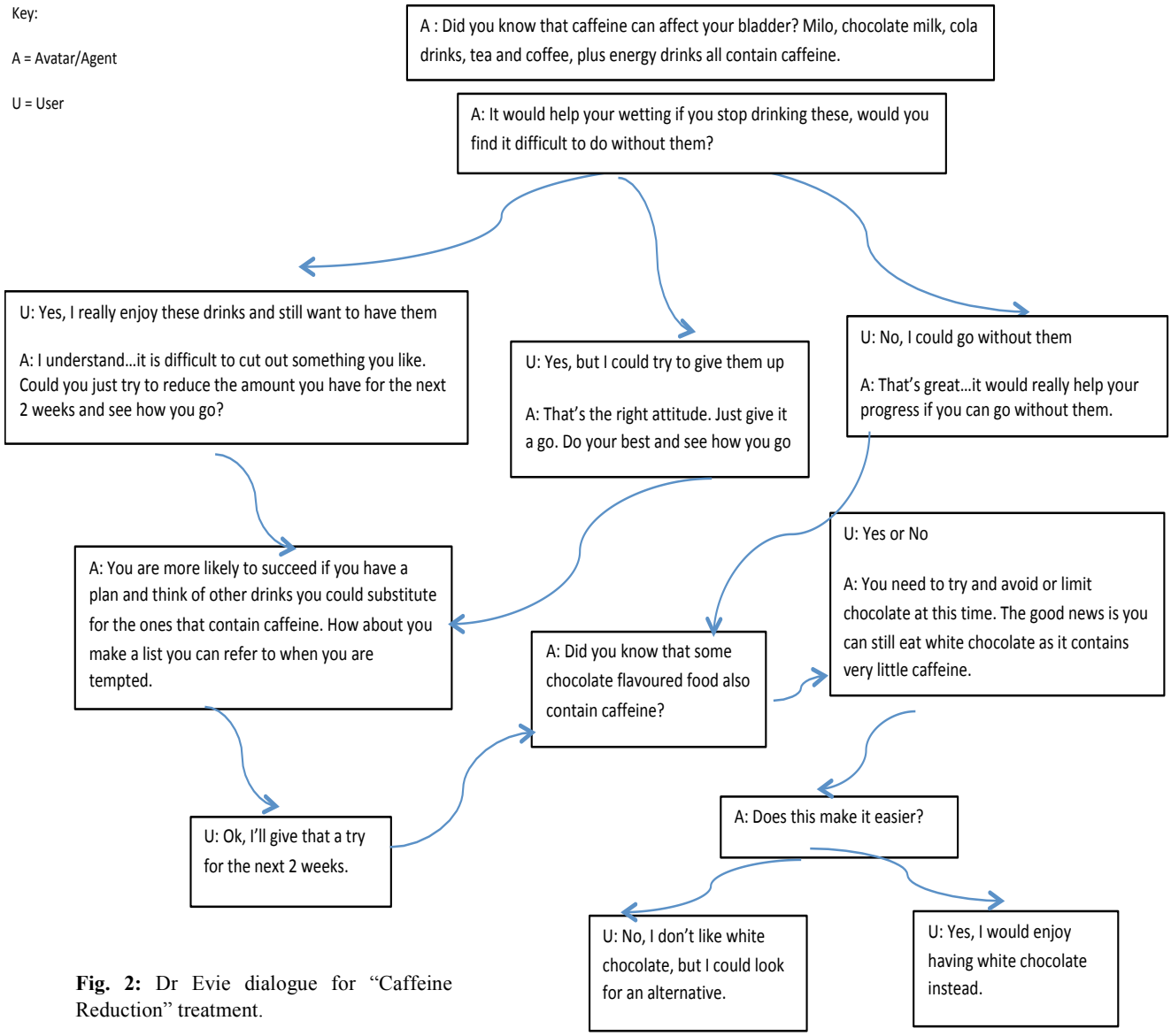

Fig. 2: Dr Evie dialogue for "Caffeine Reduction" treatment.

To build a bond, we designed dialogues to include Bickmore's [3] empathic cues: pleasure at seeing the user, social chat, empathy for the user, reciprocal self-disclosure , humor, talk about the relationship, shared knowledge and past and future together, continuity behaviors, inclusive pronouns, politeness strategies, greeting and farewell rituals (p.7). We formed these cues into a dialogue structure that commenced with a greeting followed by social and empathic chat, leading to discussion of the patient's medical history and adherence. This information allowed the treatment to be determined. For Pilots 4 and 5, Dr Evie was incorporated into the program following patients being given treatment recommendations to provide feedback, tips and explanations and goal/activity setting. The dialogue tree for the treatment "caffeine reduction" in Figure 2 recognises that change is up to the user, not the doctor. Similar to the story-sharing strategies [9], our dialogues acknowledge that it might be hard to adhere. For example, in the "timed voiding" dialogue, the patient can respond "No I won't be able to remember". There is no judgment for admission of inability or unwillingness to follow the advice "Ok, here are some suggestions to help you remember to go".

To understand what also does not work well, we have reviewed the adherence results and dialogues for the medication discussion. We found that these dialogues did not provide many options, with the main action being for the family to speak with their GP. Since parents usually do not like using drugs with their children, this outcome is not surprising. However, the dialogue is not about why they use medication or how they should use it. Ironically, the discussion is about why they should speak to their GP about medication. It highlights that these families were more

willing to speak to Dr Evie, than to speak to their GP. Perhaps since their GP had not been able to resolve their issue prior to requiring an appointment with a specialist, they may not have confidence in the GP and their knowledge about the condition and its drug treatment. In a future trial, we intend to rewrite the medication dialogues to provide more education and explanation about the medication option, more choices and consideration of alternatives and the issues, including discussion of how medication may relate to the other treatments that have been advised to give the patient the bigger picture. However, the role of the GP in prescribing medication is crucial, as we believe that a strength of the eADVICE program is that the GP is part of the loop and is part of the treatment plan. We may also need to provide more education to the GP and assist them to be more proactive in enagaging with families to discuss the treatment options and medication in particular.

4 CONCLUSIONS & CHALLENGES

Dr Evie seeks to achieve all the goals of a virtual health coach outlined in section 2. Face-to-face interaction and everyday, jargon-free language used by Dr Evie, seeks to overcome health literacy barriers. The conversations concern treatments that have been personally recommended based on knowledge of the user's current health state. Through these conversations, Dr Evie seeks to challenge current behaviours leading to improved adherence, particularly through establishing a working alliance with the patient, toward improved health outcomes.

The potential of IVAs as Virtual Coaches is demonstrated in studies, such as our own in attitude change [17] and adherence [1], and those of other researchers in overcoming health literacy barriers [4], behavior change [3; 12] as well as adherence [7],[9]. The current state of the art in Intelligent Virtual Agents (IVAs) reveals sophisticated IVAs with their own memories, personality, cultural norms and emotional maturity to listen and respond through verbal and non-verbal behaviours. What is lacking is a deep understanding of the human and integration of data mining techniques to allow the IVA to uncover users' preferences, behavior patterns, psychological or cognitive styles or other individual characteristics. With this intimate knowledge of the human the agent will be able to better decide how best to interact with them.

The ECAs we have built and evaluated exhibit a range of intelligence and sophistication. For projects where we utilised state of the art agent toolkits and frameworks, we found issues around third party software and application size limiting their current practical utility. In our deployment of Dr Evie, we used game technology and scripted decision trees for interaction and integration of the Virtual Coach into an existing website. We plan similar approaches in other domains and populations such as sleep disorders, cystic fibrosis and lower back pain education and management.

From technical and practical perspectives, solutions are needed that provide strategies for acquisition and co-evolution of user-appropriate language, dialogues and domain knowledge that comply with legislation and organisational policies and respect cultural sensitivities.

From an ethical perspective, interaction via option selection aims to 1) discourage misuse (e.g. trying to break/trick the software or train it to behave inappropriately) and 2) avoid possible misinterpretation and misunderstandings of what the agent is, can or will do (e.g. mandatory reporting of a suicidal patient). Personalised advice based on access to the user's data requires policies around informed consent and proper use of that data. ECAs should not replace humans, but play roles that a human can not play, perhaps due to availability, cost or unsuitability; we need to maintain healthy human and technology-based relationships.

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