Assessment of users' acceptability of a mobile-based embodied conversational agent for the prevention and detection of suicidal behaviour

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Abstract

The use of embodied conversational agents in mental health has increased in the last years. Several studies exist describing the benefits and advantages of this technology as a complement to psychotherapeutic interventions for the prevention and treatment of depression, anxiety, or post-traumatic stress disorder, to name a few. A small number of these works implement capabilities in the virtual agent focused on the detection and prevention of suicidality risks. The work presented in this paper describes the development of an embodied conversational agent used as the main interface in HelPath, a mobile-based application addressed to individuals detected with any of the suicidal behaviours: ideation, planning or attempt. The main objective of HelPath is to continuously collect user's information that, complemented with data from the electronic health record, supports the identification of risks associated with suicidality. Through the virtual agent, the users also receive information and suggestions based on cognitive behaviour therapy that would help them to maintain a healthy condition. The paper also presents the execution of an exploratory pilot to assess the acceptability, perception and adherence of users towards the virtual agent. The obtained results are presented and discussed, and some actions for further improvement of the embodied conversational agent are also identified.

Keywords Embodied conversational agents · Suicide prevention · Mobile health · Mental healthcare

Introduction

The development of embodied conversational agents (ECAs), as advanced human-computer interfaces, with objectives to support users with healthcare related tasks has increased in the past decade [1]. Currently, there are ECAs with capabili-

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ties to facilitate users with the searching for online health information [2], helping in the diagnosis of sleep disorders [3], the promotion of behaviour change [4], or home care and companionship for older adults [5] to name a few.

The main characteristics of an ECA are the abilities to emulate a *person to person conversation* through a combination of *dialogue interaction* represented in a *human-like appearance* with a set of *body movements* and *facial expressions*.

The main hypothesis behind the development of ECAs is that their interaction capabilities facilitate the engagement and motivation of the users, promoting a continuous and long-term use that maximise the provision of information and support.

One of the clinical domains where the ECAs are increasingly adopted is mental health. Thanks to the ECA's capabilities to emulate face-to-face conversations, there are currently several research initiatives focused on the development and evaluation of ECAs in psychotherapeutic interventions [6]. The main advantage of ECAs in this clinical domain is the possibility to approach some of the mental health services to a

significant population that currently cannot or does not get as much access to these services as required due to costs, logistical issues, stigma or convenience.

Due that in extreme cases the fatal consequence of some mental health disorders is the commitment of suicide, it is of high importance the development and evaluation of ECAs with capabilities to prevent, detect and alert about risks associated with suicidal behaviours. The development of ECAs with these capabilities deployed in mobile devices such as smartphones and tablets would facilitate its continuous (anytime, anywhere) use. This kind of Apps would be particularly relevant to reach the young population (as *digital natives* [7]) because according to the World Health Organisation, the suicide is the second leading cause of death in the 15–29 years old community which represents the 1.4% of all deaths worldwide [8].

In this paper, we present the development of a mobile-based ECA aimed to remotely monitor and support people detected with any of the three suicidal behaviours: ideation, planning or attempt. This mobile application is one of the components of a computational platform developed to support the screening, surveillance, prevention and detection of suicidal behaviours [9]. The main capabilities of the ECA are to continuously get the user's self-reported information about his/her mood state, negative thoughts, and the execution of some recommended daily activities. Using the reported data and some information taken from the user's electronic health record, the ECA provides individualised suggestions and exercises based on cognitive behaviour therapy to minimise the occurrence of relapse. Moreover, if a risk is detected, the ECA can alert via SMS to relatives or specialists (depending on the preferences of the user) seeking for direct contact support.

The paper also presents the execution of an exploratory pilot to get information about users' preferences and reactions towards the ECA, as well as the App's level of usage. Specifically, we were interested in assessing whether the ECA's emotional behaviour is perceived as *coherent*, *consistent* and *suitable* for the targeted users; as well as the promoted level of adherence to it. We were also interested in assessing any differences in the App's use according to the age and gender of the users. The obtained results from the pilot are presented and discussed. The rest of the paper is as follows: Section 2 summarises some related work. Section 3 describes the design and functionalities of the ECA, while section 4 presents the methods used for the exploratory pilot study. Sections 5 and 6 present and discuss the obtained results. Finally, Section 7 gives some conclusions.

Related Work

Previous studies have reported that stigma and geographical isolation are two of the main barriers to help-seeking for individuals at risk of suicide [10]. The use of digital interventions is one strategy to overcome these barriers offering a powerful means of delivering evidence-based interventions with higher levels of personalisation to individuals at risk and at the time when the intervention is needed [11]. Examples of these digital interventions include web-based [12], as well as commercial and research mobile applications [13], developed to contribute to the prevention of suicide. In most of the cases, the continuous and long-term use of these applications is desirable to maximise the benefits provided by the digital intervention, particularly when the intervention needs to be extended in the time for the identification of relevant changes in the user's condition.

The implemented type of interaction highly influences a constant and effective use of a computer system. Since the early '90s, several research efforts have been dedicated to the design and development of more engaging and motivating computer interfaces that facilitate the interaction with the user [14]. To achieve a more natural and smooth communication between users and computers, developers have adopted the metaphor of interpersonal communication. The emulation of interpersonal communication between a computer and the user includes the use of *disembodied* (i.e. chatbots) or *embodied* conversational agents (ECAs).

Although both types of agents can communicate with the user through speech, the main difference is the human-like physical appearance of the ECAs. Using their body, the ECAs can enrich the interaction with the user through nonverbal cues such as gestures, postures, movements and facial expressions. Some authors argue that an ECA elicits significantly more sympathetic social behaviour than those agents without physical form [15]; or that an anthropomorphised agent is perceived in some cases as more believable, comfortable and useful than a non-anthropomorphised agent [14]. The advantages of a combination from verbal and non-verbal communication are more evident when the underlying applications require the conveying of empathic responses, the building of rapport and even therapeutic alliance with the user, such as relational agents used in clinical psychiatry [16].

Based on these advantages, several research efforts have been dedicated to the development of ECAs as a complementary technological tool for people with mental health problems. In a recent systematic review, the authors found that more than half ECAs used in clinical psychology are applied to the treatment of autism followed by the treatment of depression, anxiety disorder, posttraumatic stress disorder, psychotic disorder and substance use; and the most common roles assumed by the ECAs were as social interaction partners and as coaches [6].

Regarding the development of ECAs with capabilities to detect suicidality risk, there are currently some initiatives such as SPARX-R: an online, gamified intervention containing an ECA acting as a virtual guide addressed to students (16–18 years old) of high school in the prevention of depression

[17]. SPARX-R uses three items of the Youth Risk Behaviour Survey [18] to detect suicidal thoughts, plans and attempts over the preceding month. Any of the three items activates a risk management protocol consisting in the triggering of an alert sent to the trial researchers, which in turn confidentially communicates the student's name to the school counsellor to provide immediate support.

An empathic ECA is also presented in [19], developed to identify and provide early interventions for symptoms of depression and suicide ideation in the university community. Suicidal ideation is detected through the Patient Health Questionnaire-9 (PHQ-9) [20], and when a risk is identified, the ECA offers information on pre-configured supporting contacts. Moreover, the application sends an alert e-mail to a specialist promoting face-to-face contact. After suicidal risk is detected, the ECA also offers a relaxation exercise based on cognitive behaviour therapy to provide immediate help to the user.

A third work is the Help4Mood interactive system, which also contains an ECA aimed to assist in self-monitoring of patients receiving treatment for depression [21]. Through the interaction, the ECA facilitates the self-monitoring of mood, thoughts, activity and speech to generate relevant information for both patient and clinician. Similarly to SPARX-R, the Help4Mood application also implements a crisis plan if a suicidal behaviour is detected. The suicidal risk is identified by the ECA when the patient reports more than occasional thoughts of self-harm through the PHQ-9 [20]. In this situation, the ECA prompts the user to consider contacting professional advice showing pre-defined information about specialised services. From that point on, the ECA collects only basic mood check data, and other system functions are unavailable. A more in-depth review of ECAs used for the detection and prevention of suicidal behaviour is presented in [22].

The ECA presented in this paper takes the role of a virtual interaction partner able to collect relevant user's information, provides immediate feedback and alerts if a suicidal risk is identified. The main difference of our developed ECA regarding the similar works presented above is that the detection of suicidal risk is based not only in the results of a validated questionnaire (e.g. the PHQ-9 or the Youth Risk Behaviour Survey). We have implemented a protocol for the assessment of suicide's risk using three sources of information. The first source is the data provided by the user through the interactive sessions. The second source is the set of data taken from the patient's electronic health record. Finally, the third source is the obtained results from Roberts' suicidal scale [23] used to confirm the existence of the risk and minimise the triggering of false positives.

Moreover, when a risk is detected HelPath sends an SMS to the user's relatives, friends, and/or the specialist, containing information about the location of the user taken from the device's GPS (previously authorised by the user). At the same time, HelPath puts the mobile phone in the calling mode to a pre-recorded 24/7-crisis line number. Some technical details of the ECA's development and the methodology followed for the initial evaluation are presented in the following sections.

Internal Design of the ECA

HelPath is the mobile application where the ECA is the primary interface with the user (see Fig. 1). HelPath was conceived as a complementary technological tool for the specialists can remotely monitor and collect relevant data from individuals detected with suicidal behaviours. In this sense, the specialists are responsible for assessing and deciding who the individuals to recommend the use of the App according to their clinical condition are. A pre-requisite to use HelPath is to get relevant psychological data into an electronic health record that are used by the App during the sessions with the user.

We have developed a set of four ECAs (two males and two females) for the users to choose, at the beginning of each session, their preferred ECA's appearance and clothes. A realistic appearance was developed for the four different ECAs based on previous evidence indicating that users prefer to interact with a realistic ECA in medical-related applications [24]. Moreover, previous studies also found that users tend to be more influenced by an agent of the same ethnicity [25–27]. Thus, we designed the appearance of the four ECAs with mid-dark tones of skin, eyes and hair (excepting the ECA representing an older man with a grey tone of hair) matching the mestizo ethnical group, the dominant race of the Mexican population (see Fig. 1).

The inputs from the user to the ECA are constrained to the selection of different options and values through the GUI's controls. We applied this strategy to ensure data validity and accuracy, as well to minimise errors in automatic speech recognition and natural language understanding, which is particularly important when designing health counselling interactive systems [28]. The behaviour of the ECA is dynamically generated at each interaction cycle and involves different processes (see Fig. 2). The main outcome of these processes is the behaviour of the ECA conveyed through a set of dialogues complemented with the facial expressions and body movements representing different emotions towards the user during the interaction. The next subsections detail the main ECA's internal components.

The Emotional Model

A key aspect that an ECA used for psychotherapeutic purposes should implement is the ability to generate empathic responses. As stated in [29], *empathy* is a fundamental aspect of the success of counselling and psychotherapeutic
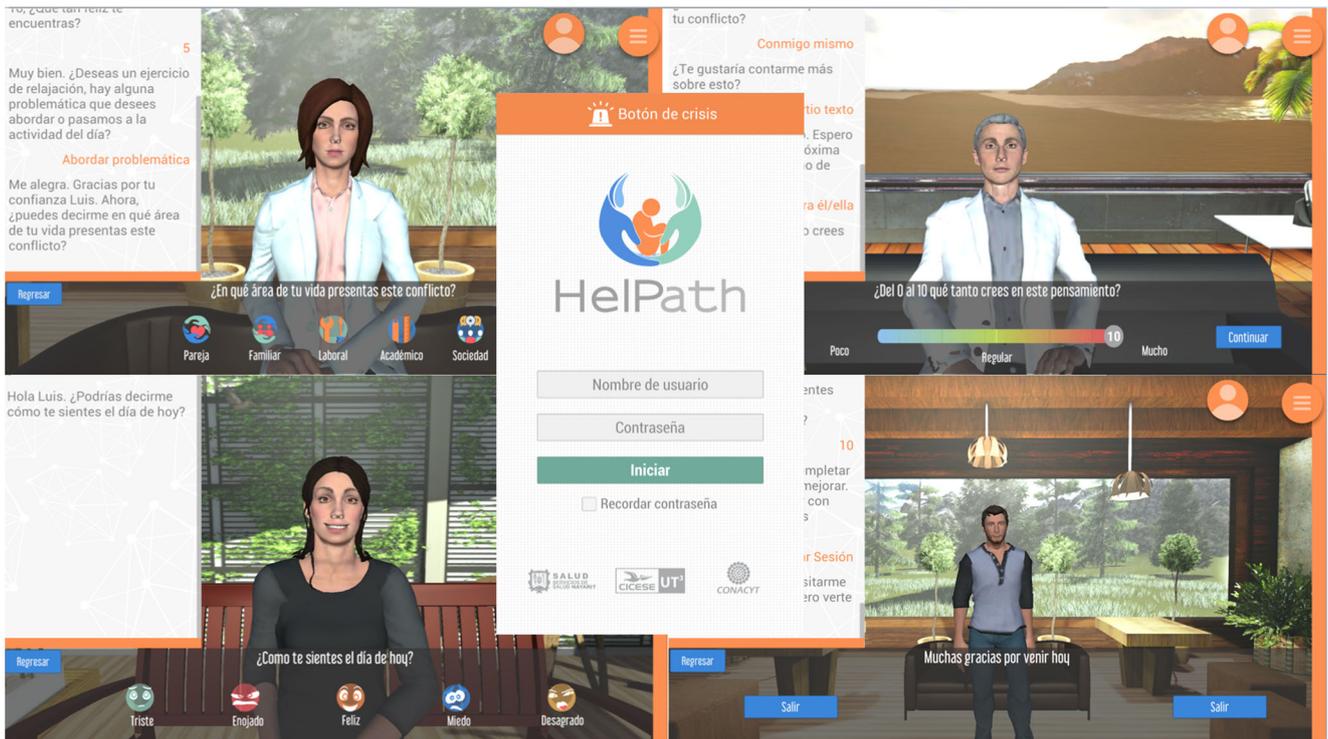
Fig. 1 Screenshots of the HelPath App with the different ECAs

interventions. Although our ECA is not intended to provide complete psychotherapeutic interventions, most of the

exercises and suggestions offered by the ECA through the interactive sessions are based on the Cognitive-Behaviour.
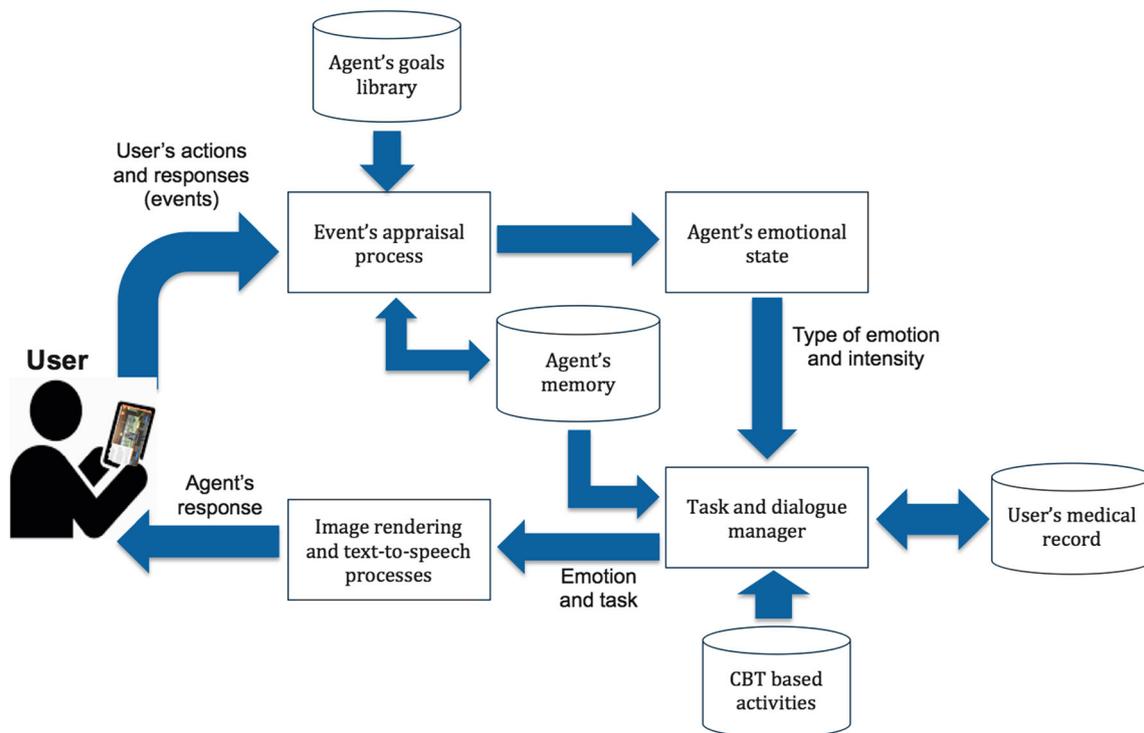

Fig. 2 The internal components of the ECA

Therapy (CBT). Thus, it is useful for the conveying of empathic reactions during the interaction that contribute to building a trustworthy relationship with the user. Such a relationship would facilitate the continuous and long-term use of HelPath maximising its utility for the target users.

The emotional model implemented in HelPath's ECA is based on the cognitive appraisal theory of emotions [30]. The core concept of the cognitive theory of emotions postulates that an individual continually evaluates the events produced in a person's environment. This cognitive evaluation -i.e. appraisal- process leads to an emotional response (depending on the relevance of the event for the person), which in turn generates a specific behaviour to cope with the appraised events. As can be seen in Fig. 2, we implemented the appraisal derivation component responsible for evaluating all the events (user's inputs) according to a pre-defined (using XML files) set of goals for the ECA. The set of pre-defined goals are related to the ECA's objective of collect user's information and to provide with specific CBT-based activities. Depending on the result of the event's appraisal, a particular emotion with a given intensity is generated. For the implementation of the appraisal and affect generation processes, we have used the emotions and appraisal variables defined in the OCC model [31]. In this sense, the implementation of our emotional model is similar to other existent works such as those presented in [32, 33].

Moreover, during the appraisal process, we also use the information collected in previous sessions to generate adequate empathic responses towards the user. For example, during the interaction, the user reports that he/she is feeling a negative emotion with some intensity. The ECA can appraise this event as *undesirable* for the user's condition, which in turn would produce (empathically) an ECA's negative emotion with a given intensity. Nevertheless, a *pure* empathic reaction in these cases can be interpreted as a sympathetic expression of condolence that may imply a kind of agreement with the user's (negative) feeling [34]. Such type of empathic response would not be suitable for the intended purposes of the application.

Thus, using the information from previous sessions, the ECA realises that the user previously reported the same negative emotions but with higher intensity. The ECA then can assess if there is a positive tendency in the reduction of the intensity of the negative emotions reported by the user in the last sessions. If a positive tendency is found, the original event is *reappraised* as *not much undesirable* to the user (thought the current user's emotional state is still not the optimal). This reappraisal can change the ECA's affective state and/or the corresponding emotion's intensity, which is reflected in the feedback provided to the user. This process acts as an emotion regulation component used to generate better contextual responses according to the information reported by the user [35].

The Task and Dialogue Manager

All the spoken responses from the ECA to the user are based on a set of CBT-based activities aimed to collect relevant information (e.g. user's irrational thoughts) and provide useful feedback (e.g. the provision of alternative rational thoughts). The utterances to communicate the specific feedback and the next CBT task to do are constructed in the task and dialogue manager (see Fig. 2). Depending on the inputs provided by the user, the task and dialogue manager selects different utterances defined in an XML-file based on *i)* the emotion generated by the emotional model; *ii)* the information stored from past sessions and, *iii)* the pre-defined set of CBT activities. Every agent's response is dynamically formed consisting of two parts. The first part is the *empathic* feedback to the previous user's input and depends on the emotion generated by the emotional model. The second part is the explanation or suggestion for the next CBT-task to do.

Depending on the responses of the patient and on the activities already developed during the current session, the task manager offers the remaining CBT-tasks for the patient can choose the specific type of activity to perform next. In this way, the session with the ECA can be shorter or longer, and the order in the execution of the activities varies from session to session based on the condition and preferences selected by the patient. These changes in session's duration and the order of the execution of the CBT-based tasks are essential to avoid the generation of sessions with exactly the same content, which can decrease at some point, the interest of the patient in the use of the application [36].

CBT-Based Activities

Based on the evidence about the use of CBT in the reduction and prevention of suicidal cognitions and suicidal behaviours [37, 38], we have implemented five modules based on principles of the CBT. The ECA is responsible for offering most of the content and motivate to the user in the execution of the recommended activities. The five CBT-based activities are summarised in the following subsections.

Psychoeducation An important initial phase of a CBT-based intervention is to dedicate some time to explain the user about their symptoms, describe an explicit conceptualisation of the problem, introduce the basic principles and goals of CBT, and how it can help them [39]. Thus, the first time that the user enters into HelPath, the ECA introduces to the user a psychoeducative video where a combination of cartoonish images in movement with a narrator explaining the main components of the CBT is displayed. In subsequent sessions, the user can visualise the video at any time through an option in the App's main menu.

Monitoring of the Emotional State A key element in CBT is to support the patient with the ability to be self-aware and reflective of his/her emotional states, thoughts and behaviours. The first activity during a session, after the ECA's welcome, is to ask the user about their feelings. The ECA questions about what emotion is the user feeling today. The user has the option to select any of the five basic emotions (sad, angry, happy, disgust and fear) or *"none of these"*. Once the emotion is selected, the ECA asks the user about the intensity of that emotion, offering a slider for the user to choose a value between 1 and 10. When the user does not select any of the five basic emotions, the ECA asks *"How is your mood today?"* and the user responds by using a slider representing values from bad to good mood. The self-reported emotions/mood and their intensities are stored for the further assessment of the user's condition and for the summary reports that are integrated into the user's electronic psychological record.

Cognitive Modification Our ECA supports users with cognitive modification by implementing activities based on the *ABC-DEF* framework of Rational-Emotive Behaviour Therapy - REBT (a particular form of CBT) [40]. The activity starts when the ECA asks the user by a possible *activating event (A)*, that generates a possible conflict. In particular, the ECA requests for the area (family, work, academic, social or partner) of that possible conflict. Then the ECA asks the user if the conflict is with him/herself, with others or with life. This information is used to categorise the (irrational) *belief (B)*, allowing the ECA to offer a set of 5–7 irrational beliefs (IB), according to the identified category. After the user selects one of the provided IB, the ECA asks about the believability of the user on that IB and what is the emotion elicited by it. This information is used to assess the emotional *consequences (C)* of the IB.

After the *ABC* of the conflict is identified, the ECA offers the *disputation (D)* of the IB by asking three questions: *i)* what is the evidence the user has on that IB? *ii)* How much the user considers useful the IB? And *iii)* whether the user can provide some other explanation to that IB. After collecting the user's responses, the ECA offers an alternative (rational) belief trying that the user replaces the IB by an *effective (E) new belief*. Finally, to promote the co-construction of more *functional (F) emotions and responses*, the ECA suggests the execution of an activity related to the offered rational belief to practice and reinforce it. Additionally, the ECA asks about what the user has learned, how much he/she now beliefs on the original IB and whether there was some change in the initial reported emotion or mood. All this collected information is used for the assessment of a possible cognitive change in the user.

Behavioural Activation The behavioural activation focuses on activity scheduling to encourage patients to approach relevant and satisfactory activities helping to develop protective factors against suicidality risks. The ECA offers a set of activities to schedule a maximum of five during the current week aiming to get a commitment from the user. The ECA provides two types of activities: those addressed to develop personal and social abilities (such as interpersonal relationships, self-discovery or conflict resolution); and those for activation such as practising sports, art, religion, watch movies, among some others. Once the week's activities are set, HelPath sends reminders highlighting the importance to execute them and offers the option to re-schedule those activities not reported as performed on the planned day. When the deadline of each activity arrives, the ECA questions the user whether he/she performed the activity, what were the obstacles faced during its (no) execution, and for the cases of the executed activities, what was the obtained satisfaction level.

Relaxation Exercises The main goal of relaxation is to reduce the physiological activation produced by stressful events, facilitating the recovery of a well-being state. HelPath offers the patient with four relaxation exercises. Two of these exercises are based on Jacobson's progressive muscle relaxation exercises (PMR) involving muscle tension and relaxation [41]. The other two exercises are based on controlled and deep-breathing relaxation techniques. The ECA explains the content and objective of each relaxation exercise for the user makes a selection. After selection, a video with a pre-recorded voice guides the patient through the exercises while some images are displayed on the screen. Once finished, the ECA asks again to the user about his/her current emotional state to assess whether the relaxation exercise had a positive effect or not to the user's condition.

Detection of Suicide's Risk One of the main HelPath's functionalities is the detection of factors associated with suicidality risk. The identification of these factors is based on some clinical data retrieved from the user's electronic health record, and on some of the self-reported information during the interactive sessions with the ECA. The risk factors associated with suicidality are identified taking as reference the SAD PERSONS scale [42]. This scale consists of 10 items (each one corresponding to each scale's name letter) assessing a risk factor for suicide: **S**ex, **A**ge, **D**epression, **P**revious attempt, **E**thanol abuse, **R**ational thinking loss, **S**ocial supports lacking, **O**rganised plan, **N**o spouse, and **S**ickness. Each factor is scored 1 if present and 0 if absent, resulting in a cumulative score that is interpreted as conveying a specified level of risk.

Depending on the data provided by the user during the sessions, the assessment through SAD PERSONS is triggered only when any of the following conditions occur:

1. **Drastic or sudden changes in the user's emotional state.** These changes are identified when the patient reports a high positive emotion/mood during three or more

consecutive sessions, and then he/she reports a high negative emotion/mood. Also, if during the same session the initially reported emotion is highly positive, but after the execution of some suggested activity the patient reports a high negative emotion, the scale is applied.

2. **Suicidal thoughts.** When the patient selects any of the irrational beliefs categorised as hopelessness, negative views about self, verbalisation about the dead, or possibilities to commit suicide.

3. **Cognitive rigidity.** Identified when the patient reports a high level of believability on any IB, even when the ECA has offered an alternative rational belief.

4. **Recurrent negative thoughts.** Detected when the patient selects three or more consecutive times the same IB, but not classified in any of the categories of the above point 2.

5. **Difficulties in the execution of planned activities.** Identified when the patient reports three or more consecutive times that he/she found obstacles to execute the planned week activities, independently whether the activities were reported as completed or not completed.

6. **Vulnerability to stress or adverse events.** Obtained when the patient reports a high negative emotion/mood, he/she performs a relaxation exercise, and the reported emotion/mood after the exercise is still highly negative.

When SAD PERSONS is triggered, the values of nine of the ten items of the scale are obtained from the electronic health record. The only item obtained from the patient during the interaction with HelPath is the rational thinking loss, by assessing the irrational beliefs selected by the patient using the same condition explained in the above point 2. If the patient obtains a score equal to or greater than 7, then he/she is considered within a high-risk population, and the Roberts' Suicide Ideation Scale [23] is applied to assess the imminence of suicidal behaviour and to minimise the occurrence of false positives.

The Roberts' scale has been validated in Mexican population [43], and it consists of four items regarding thoughts about death and taking one's own life over the previous seven days. A four-point scale is used with the options: 0 = 0; 1–2 days = 1; 3–4 days = 2; and 5–7 days = 3. The overall score ranges between 0 and 12 points. When the obtained score is equal to or greater than five points, HelPath sends an alert SMS to all the user's contacts (defined by the user in the settings of the App) requiring making a call to the user. Moreover, if the user authorises and the GPS is activated, the SMS includes the location of the user to facilitate direct contact. At the same time, the ECA informs the user about the SMS sending and suggests the user make a call putting the mobile phone in a call mode showing his/her contact numbers including the crisis line number. After that, the ECA explains the situation again and emphasises that even in the case the user decided not to make the call, his/her contacts were informed and warned about the user condition to facilitate direct and personal contact. Then, the agent finishes the current session.

For those cases, when the score of the Roberts' scale is lesser than five, the ECA suggests the patient make a call looking for social support. In these cases, no alert messages are sent, and the session can continue and finalises as usual. It is important to mention that as a complement to the mechanism for the automatic detection of suicidality risk, HelPath also implements a crisis button that is accessible from the App's menu or even from the login screen (see Fig. 1). When the patient selects the crisis button, HelPath shows the list of the pre-defined contacts for the patient to choose the person to make a call. When the patient decides the specific contact, the mobile phone is put on a call mode, and at the same time, the alert messages are sent to the whole list of contacts. In this way, we try to minimise the risk that the patient's selected contact is not available to answer the call and warn about the situation to the other pre-defined contacts.

Image Rendering and Text-To-Speech

Once the specific ECA's utterance is formed with the feedback to the patient and with the next CBT-based activity to recommend, the verbal and nonverbal communication is conveyed by the ECA. This communication is generated through two channels: the non-verbal and verbal behaviours. The non-verbal behaviour is modelled through the facial expressions and body movements corresponding to the specific emotion produced by the emotional model. Verbal communication is the translation of the formed utterance into the ECA's speech. For this process, our App uses the text-to-speech software and the male/female default voices provided by the mobile device. The facial expressions are generated taking into account the intensity of the modelled emotion (e.g. a high intensity in the OCC's model-based "JOY" emotion is represented with an open smile, while the same emotion with small intensity is represented with a closed smile).

Moreover, the ECA's non-verbal behaviour is also conveyed through two types of specific body movements. We have modelled some body movements dependent on the dialogue provided by the ECA. For example, when the ECA asks the patient to select one of the options shown on the screen, the ECA move the arms and hands to point the available options. Also, at the end of the session, the ECA stands up and moves the hands representing a farewell. There are also some other body movements that are randomly generated to represent idle behaviours. These movements include, e.g. the movement of the shoulders representing ECA's breathing, the crossing of the legs, or a slight look around. All these movements are displayed when no specific input from the patient is detected to make the ECA more believable and avoid the zombie effect [44]. Moreover, if the input from the patient is not received

after 1.5 min, the ECA asks if the patient is still there and repeats the previous requesting to the patient.

Evaluation

Methods

After the design and implementation of the ECA as the main interface between HelPath and the user, it is essential to assess whether the appearance and behaviour of the ECA have positive effects regarding acceptability and adherence to the App in the addressed users. Thus, an exploratory study was designed where individuals with antecedents of suicidality were invited to participate by using HelPath on a daily basis. After use, objective (App logs) and subjective (user's feedback through a questionnaire) data were analysed to identify the level of usability of the App (concerning the number of HelPath's sessions), as well as the acceptability and adherence levels towards the ECA.

Procedure and Participants

During June 2018, a group of 32 individuals with suicidality antecedents was identified by the mental health specialists involved in the development of HelPath and all of them were invited to participate in the pilot. After an informal explanation about the main features of the App, and the objective of the pilot, six individuals declined to participate, and four mentioned that they only use iOS smartphones. At the moment, the HelPath App is only available for Android smartphones, so a total of 22 individuals were selected to participate in the pilot.

The pilot was designed by starting with an initial interview carried out by the psychologists of the HelPath's project, to assess the current clinical condition of the volunteers. For safety reasons, as the objectives of this exploratory pilot also included the identification of any bug or malfunctioning of the App, we decided to involve at this stage only those individuals identified with any suicidal behaviour (ideation, planning or attempt) at least one time during his/her life but not at the present or recently. The complete list of the defined exclusion criteria for this pilot is the following:

- Individuals under pharmacological treatment.
- Presence of mental disorders such as schizophrenia, psychosis or borderline personality.
- Addiction to alcohol or other drugs.
- Presence of recent (in the last six months) suicidal behaviour (ideation, planning or attempt).
- Absence of previous (before the last six months) suicidal behaviour.
- Any disability that prevents the participants from using the mobile device.

- Presence of severe or very severe anxiety.
- Presence of severe or very severe major depression.
- Not able to live at home, in the community (or need constant personal monitoring).

Once assessed, a total of 18 volunteers were able to participate, comprising 11 women and 7 men; the average age was 31.5 ($SD = 10.3$) in a range from 20 to 53 years old. Those excluded due to recent suicidal behaviour or identified with major depression were referred to mental health specialised services. For the included individuals, some of the data collected during the assessment interview were stored in the electronic health record for their further use in HelPath (see details in the Subsection *"Measures"* below). An informed consent letter to participate in the pilot was signed for each volunteer specifying that if desired, they can leave the pilot at any moment. After that, the specialists provided all the instructions and data to download and install HelPath in the mobile devices of the participants. The participants were instructed to use HelPath for 8 weeks on a daily basis and receive a fortnightly face-to-face follow-up interview with the specialist during the execution of the pilot. The participants were also advised about the sending of the SMS alerts to the people set as contact persons. An exit interview was applied at the end of the 8 weeks of HelPath's use. During the exit interview, the participants answered a Likert based questionnaire to evaluate the acceptability and adherence level promoted by the ECA. A total of 12 participants completed the whole process of the pilot. The Fig. 3 presents the flow path of the participants included, excluded and those that completed the entire pilot.

Measures

During the initial interview, all the volunteers answered three standardised questionnaires to assess their condition and decide their participation according to the inclusion/exclusion criteria. The first questionnaire was the Hamilton Depression Rating Scale of 17 items [45], using the validated Spanish version [46]. Eight of the 17 items are scored on a 0–4 point scale and nine are scored from 0 to 2. A total score of 0–7 is considered as being normal, 8–16 suggests mild depression, 17–23 moderate depression and score over 24 are indicative of severe depression. For the inclusion in the pilot, we consider individuals with a score ≤ 24.

The second questionnaire used during the initial interview was the Spanish validated version [47] of the Plutchik Suicide Risk Scale [48]. This scale contains 15 self-report items that should be answered with "yes" or "no" describing the degree to which an individual reveals characteristics similar to those of a suicide prototype. The obtained total score ranges from 0 to 15 including no suicide risk (0–5); suicide risk (6–9); and high suicide risk (>10). All the volunteers scoring >5 were included to participate.
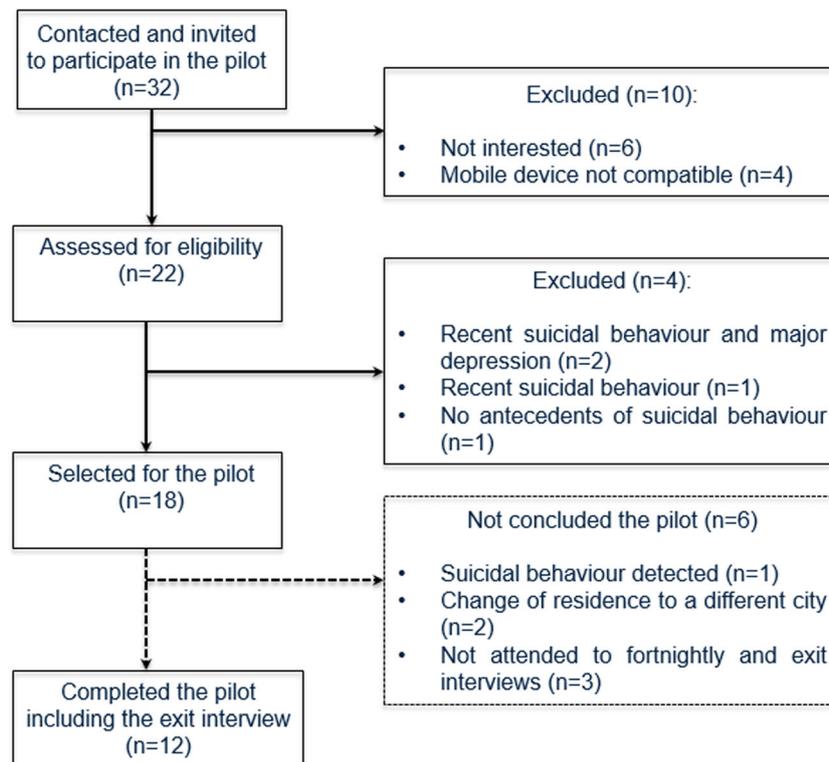
Fig. 3 Flow chart of participant selection and completion of the pilot

The third questionnaire was the Hamilton Anxiety Rating Scale [49] implemented in its Spanish validated version [50]. The scale consists of 14 items, each defined by a series of symptoms, and measures for both psychic and somatic anxiety. Each item is scored on a scale of 0 (not present) to 4 (very severe), with a total score range of 0–56, where <17 indicates mild severity, 18–24 mild to moderate severity, 25–30 moderate to severe, and > 30 severe to very severe. We included all the volunteers scoring ≤30. The results of the three questionnaires were stored in the participant's electronic health record. Additionally, some personal and socio-demographic data were also collected to get the information required by the SAD PERSONS scale during the use of HelPath (see Subsection "Detection of suicide's risk" above).

During the fortnightly follow-up meetings, the specialists carried out unstructured brief interviews to know whether the user has any problem with the use of the App, and reinforce the suggestion of its daily use. At the exit interview, all the users were provided with a Likert-based questionnaire containing seven items to assess three important ECA's features (see Table 1). The first item (Q1) was included to get user's assessments on the ECA's appearance. This feature was included based on previous research that acknowledges the high influence of ECA's appearance on user's motivation, interest and attitudes towards the recommended tasks or messages received from the ECA [24, 51, 52]. Three items (Q2-Q4) were considered to assess the *emotional competence* of the

ECA. The emotional competence is referred to convey a coherent and consistent emotional behaviour during the interaction with the user [53], which is particularly important in ECAs designed for psychotherapy [16, 54].

Additionally, three items (Q5-Q7) were included to assess the level of adherence promoted by the ECA, where trustworthiness is considered a key aspect to maintaining a long-term interaction with an ECA and more effective use of the application [55, 56]. Responses to each question include the values 1 = *"Strongly disagree"*; 2 = *"Disagree"*; 3 = *"Neither disagree nor agree"*; 4 = *"Agree"*; and 5 = *"Strongly agree"*. The text of all seven questions was agreed among the clinicians and technicians of the project and tested with five individuals external to the project. This process was done to assure that each item is well understood and correctly capture the collection of the intended data. An extra open-text question was included to get the feedback about any aspect the users consider useful to improve the interactive sessions with the ECA.

Results

The questionnaire's responses from the 12 participants that concluded the pilot were collected and analysed using the IBM SPSS statistics software ver. 24. The first step in the

Table 1   Likert questionnaire for the ECA's assessment

Number	Question	Anchor 1	Anchor 5	Assessed feature
Q1	The appearance of the virtual agent is pleasant	Strongly disagree	Strongly agree	Appearance [24, 51, 52]
Q2	The virtual agent behaves cold and aloof	Strongly disagree	Strongly agree	Emotional competence [53]
Q3	The virtual agent acts emotionally stable	Strongly disagree	Strongly agree	
Q4	I am comfortable with the emotional responses of the virtual agent	Strongly disagree	Strongly agree	
Q5	The virtual agent is trustworthy	Strongly disagree	Strongly agree	Level of adherence [55, 56]
Q6	I would like to continue interacting with the virtual agent	Strongly disagree	Strongly agree	
Q7	The virtual agent motivates me to use the HelPath App on a daily basis	Strongly disagree	Strongly agree	

analysis was to get the evidence that the grouped items of the scale measuring the emotional competence (Q2-Q4), and the level of adherence (Q5-Q7), are sufficiently inter-correlated which represent a suitable measure of each construct. Table 2 shows the inter-correlation matrix of the items used to measure each variable, obtaining a Cronbach's alpha $\alpha = 0.894$ for emotional competence and $\alpha = 0.859$ for the level of adherence.

After grouping the items corresponding to the two constructs (using the mean score), the graphs in Figs. 4 and 5 present the results of the ECA's emotional competence (using the values 1–2: not emotionally competent; 3: neutral; 4–5: emotionally competent) and the adherence level (using the values 1–2: not adherence; 3: neutral; 4–5: with adherence). As for the assessment of the ECA's appearance, only one item (Q1) was used, and the results are shown in Fig. 6.

Moreover, a one-sample t-test was performed to test for differences from the neutral (middle) value of 3 ("Neither disagree nor agree") to the values of each construct. Table 3 presents the descriptive statistics for the collected measures. The one-sample t-tests indicate that responses related to ECA's emotional competence and the level of adherence were significantly higher ($p < 0.05$) than the neutral point on the test scale. For the ECA's appearance, no significant difference from the neutral position was found.

Table 2   Inter-correlation matrix for the individual items used to assess the ECA's emotional competence and the level of adherence

Emotional competence (N = 12; Cronbach's α = 0.894)

	Q2 (reversed)	Q3	Q4
Q2 (reversed)	1.000		
Q3	0.640	1.000	
Q4	0.762	0.860	1.000

Level of adherence (N = 12; Cronbach's α = 0.859)

	Q5	Q6	Q7
Q5	1.000		
Q6	0.745	1.000	
Q7	0.627	0.709	1.000

Regarding the feedback obtained from the participants through the open-text question, most of the comments (N = 6) were suggestions related to the improvement of the ECA's voice. Examples of this feedback include:

- *"I would like to hear the agent more like a person than like a robot"*
- *"I would change the agent's voice,* [the current voice] *was unappealing and not well understandable"*
- *"I would like* [the agent to have] *a more real voice"*
- *"The agent is unattractive and the artificial voice could be awkward"*
- *"Change the* [agent's] *voice"*

Other suggestions (N = 3) were related to having a more sophisticated dialogue interaction with the ECA:

- *"I would like* [that the ECA] *provides me with more different responses according to how I feel when I am interacting with it"*
- *"I would like to talk about more different problems"*
- *"I suggest increasing the capability to offer more diverse responses"*

Some other participants (N = 2) suggested the personalisation of the ECA's appearance:

- *"I would like to create my own agent"*
- *"I would like to have the option to choose different features to create the agent"*

Finally, only one participant suggested an improvement in the expressiveness of the ECA:

- *"[The agent]* should have a more expressive face, an affectionate look"*

In terms of the App's usage, the average of the sessions' number carried out by the users with the ECA was 18.42 (SD = 19.82), and in terms of sessions' total duration (in minutes) was 84.51 (SD = 89.30). At the individual level, the obtained
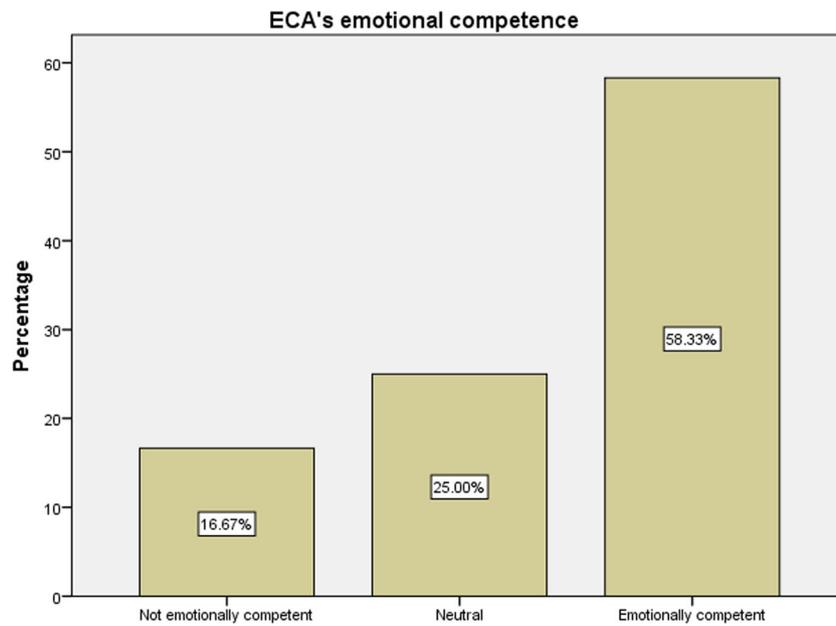
Fig. 4 Percentage of responses assessing the ECA's emotional competence

results indicate high differences between the participants. While one participant only used HelPath once (the duration of this session was 0.63 min), other participant carried out 60 sessions (resulting in a total of 5.2 h of interaction with the ECA), representing a daily use during the two months of the pilot.

Figure 7 and Fig. 8 present the graphs of HelPath's use by the 12 participants divided by gender and age. Spearman's ρ showed that the age and gender of the participants do not correlate with the sessions' number nor the session's duration average (Table 4). From the four designed agents, most of the sessions were carried out with the female agents. The agent representing an older adult was selected only in two interactive sessions (see Fig. 9). No correlation was found between age and gender of the participants and their preferences to interact with a male or female ECA (see also Table 4).

It is also important to mention the triggering of an (SMS) risk alert during the pilot. This alert was generated after a participant selected one of the irrational beliefs categorised as suicidal thoughts (particularly, the selected thought was related to *hopelessness*). According to the defined protocol (see subsection "Detection of suicide's risk"), the selection of this thought activated the evaluation of risk factors through
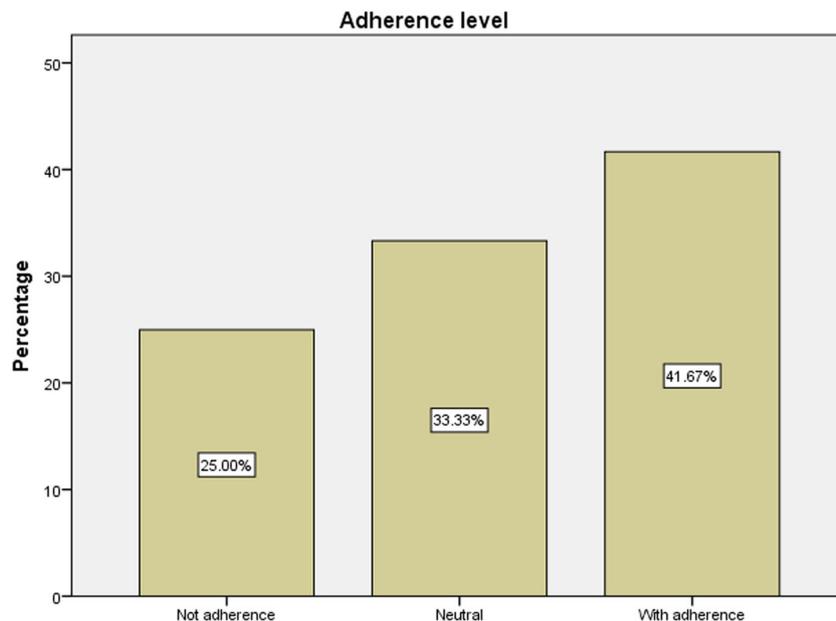

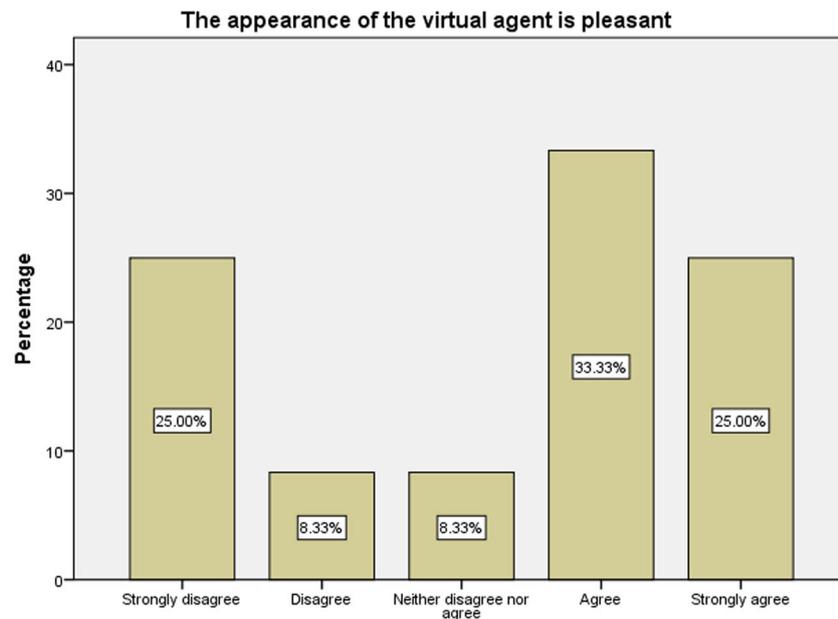**Fig. 5** Percentage of responses assessing the level of adherence towards the ECA

Fig. 6 Percentage of responses assessing the ECA's appearance

the SAD PERSONS scale. The obtained score indicated that the participant was within a high-risk population, and then the Roberts' scale was also applied. The result of the Roberts' scale generated the alert that was received by one of the psychologists of the project. The participant was contacted, and after a brief assessment by phone to discard any imminent risk of suicide, a personal interview was arranged. After the personal interview with the psychologist, it was decided to refer the participant towards the mental health care services. As the inclusion criteria for this first pilot was to involve participants without relevant and recent problems associated with suicidal behaviour, the use of the App was withdrawn to the participant (see Fig. 3). The reasons for exclusion were explained, and the participant signed an information letter. The triggering of this alert was produced after a month of use of HelPath, and until that moment, the participant carried out 15 sessions with the ECA, representing one session every other day.

Discussion and Limitations

In general terms, the results collected from the participants through the exit questionnaire show that the ECA's emotional competence and the promoted level of adherence were rated as

positive, as reflected in the responses to questions Q2-Q7. Moreover, the ECA's emotional competence was acknowledged by almost 60% of the participants. However, opportunities for improvement exist for the two aspects as the obtained average scores are closer to the neutral point in the Likert scale than to the maximum values. The value that did not get significant differences from the neutral point of the scale was corresponding to the ECA's pleasant appearance. Nevertheless, most of the open-text suggestions for the ECA's improvement received from the participants were related to the enhancement of the synthetic (male and female) voices used by the different ECAs. Only one comment was explicitly referred to as the lack of attractiveness in the ECA's appearance.

As previous studies suggested [57, 58], the characteristics of synthetic voices could be an essential aspect that influence (positively or negatively) the general perception and acceptability of the ECA to the users. Thus, a limitation of this study was the use of only one question to assess the ECAs' appearance. More precise information could be obtained if different items (similarly to the assessment of the emotional competence and the level of adherence) were used to get the user's preferences to different aspects related to the appearance of the ECA. Such items should include specific questions about ECA's physical appearance (e.g. hair, eyes), their voices, and

Table 3   Descriptive statistics and one-sample *t*-test of the three measures

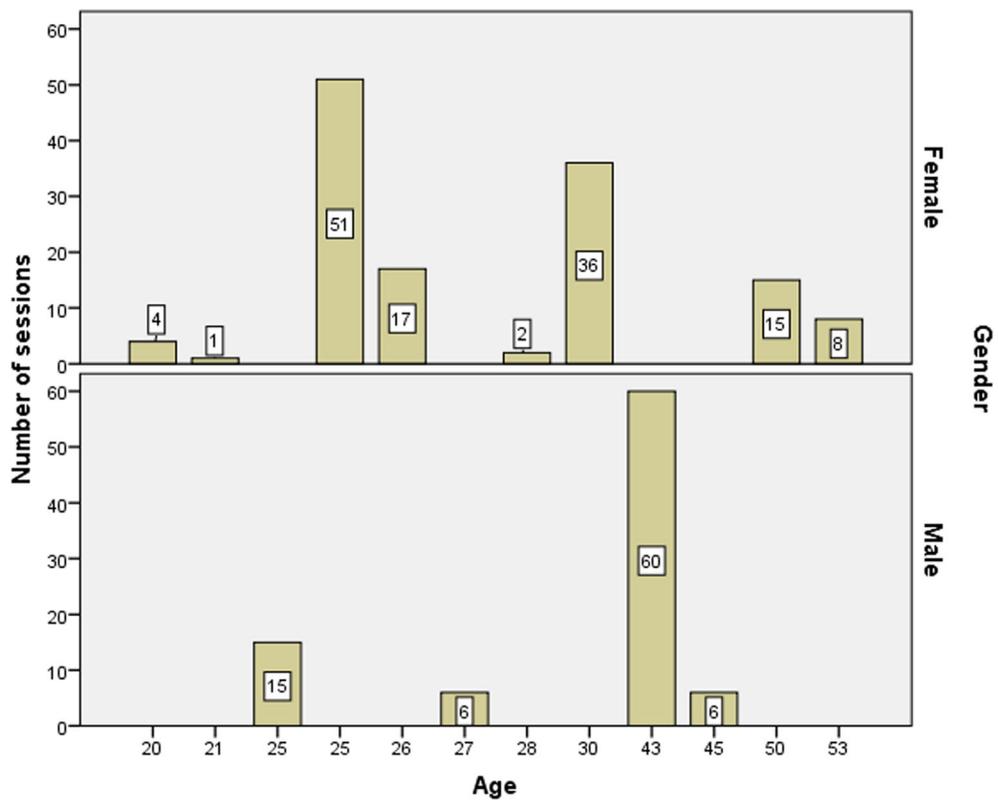| Measure	Mean	SD	Neutral value	Sig. (*p*)	Lower	Upper
ECA's appearance	3.25	1.60	3	0.600	−0.77	1.27
ECA's emotional competence	3.72	0.75	3	0.007	0.25	1.20
Level of adherence	3.58	0.87	3	0.042	0.02	1.14

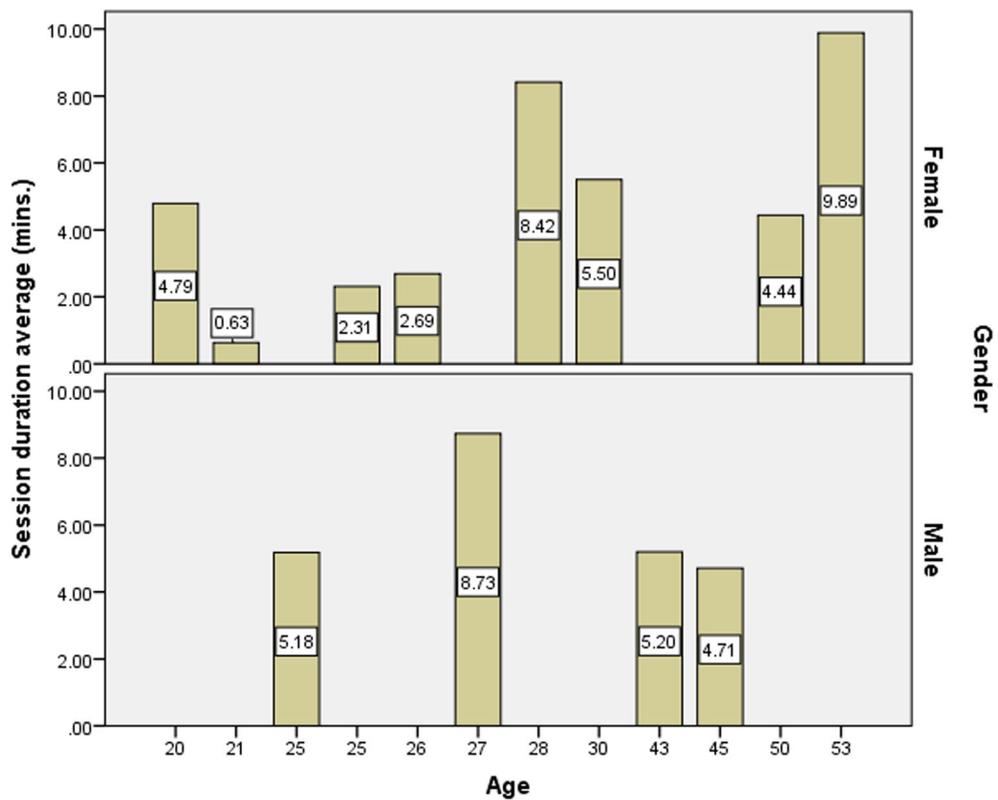Fig. 7 Number of sessions of the twelve participants

Fig. 8 Session duration average in minutes of the twelve participants

Table 4 Correlation (Spearman's ρ) of age and gender with number of sessions, session's duration average and number of sessions with a male/female ECA

	Spearman's ρ	Age	Gender
Number of sessions	Correlation coefficient	0.255	−0.128
	Sig. (p)	0.424	0.691
Sessions' duration average	Correlation coefficient	0.459	−0.256
	Sig. (p)	0.134	0.422
Number of sessions using a female agent	Correlation coefficient	0.216	−0.051
	Sig. (p)	0.500	0.874
Number of sessions using a male agent	Correlation coefficient	0.441	−0.403
	Sig. (p)	0.151	0.194

even the different worn clothes. This information will help to identify better what ECA's appearance features require more efforts for improvement.

As mentioned in subsection "Image rendering and text-to-speech", our ECAs currently use the text-to-speech and voices provided by different mobile devices. This decision was taken to maintain as easy as possible the installation of HelPath by the users, and avoid the inclusion of extra-features that, in some cases, are not compatible with different models of devices. Even using these functionalities provided by the mobile device,
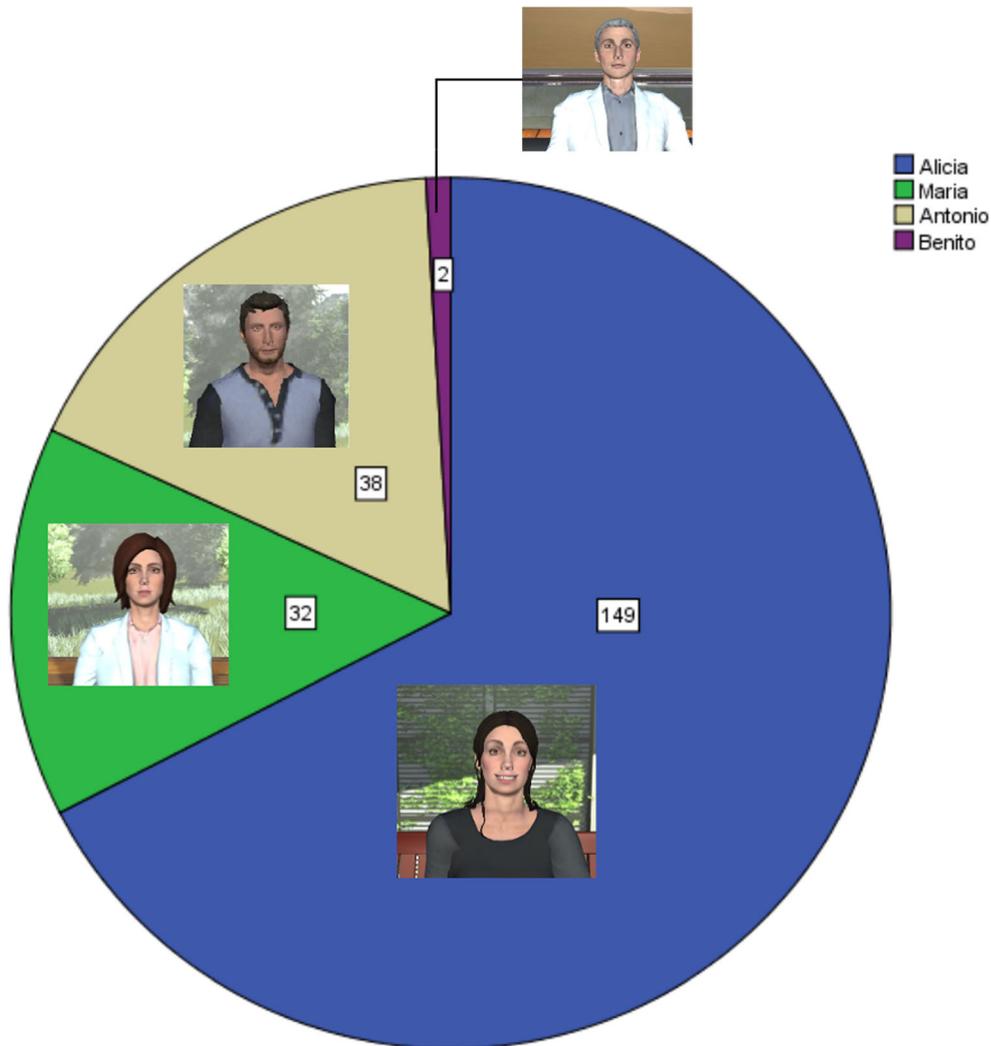

Fig. 9 Number of sessions carried out with each agent

for some models was necessary a manual configuration of some settings for the App correctly uses the male and female voices. Depending on the model, some devices use the voices provided by Google's Android operative system, and some others use the voices provided by the manufacturer of the device. In any case, all these voices are synthetic and artificial-sounding with no realistic emotional intonation. Although significant advances have been achieved in the emotional speech synthesis [59], there are still several challenges to get a natural sounding, device-independent and ready-to-use synthetic emotional speech.

The collected results about the interaction of the participants with the ECA during the two months of the pilot indicated high differences between the participants. The number of sessions carried out by the participants ranged from 1 to 60. The duration average of each session also differs between participants ranging from 2 min (excluding the 0.63 min of the participant that used HelPath once) to almost 10 min. These results are in line with previous studies that also report divided levels of acceptability of ECAs, suggesting that in the mental health domain, intra-personal differences have relevant influence on the preferences and acceptability towards the use of ECAs, and even that the use of this interactive technology might not be suitable for everybody [60].

Interesting feedback was obtained from the participants during the fortnightly interviews. When asked about the use of HelPath, some of the participants reported that they used the App when they *feel the need to use it* and not on a daily basis. These participants argue that, e.g. when feeling stressed, they entered into HelPath to perform the relaxation exercises, or when they wanted to plan some activities, they interacted with the ECA to get suggestions about what activities to do. Even one participant reported that interacted with the ECA only when was in a *low mood*. These comments suggest that the use of HelPath would be useful also if it is not used daily. The initial objective was to have the patients continuously (ideally day-to-day) monitored, but the collection of information received in those cases, e.g. when the patient is feeling bad, is also clinically relevant for the specialists and can also be used to detect risk situations. Of course this hypothesis needs to be validated with a further study involving a higher number of participants with a recent suicidal behaviour detected.

No significant correlation was found between the HelPath's level of use nor the selection of a male or female ECA, regarding the age and gender of the participants. Although some previous studies present results indicating preferences towards ECAs matching the gender of the user [61], our results are in line with some others, though not in the mental health domain, where no significant preferences towards the ECA's gender are evident [62, 63]. Almost 82% of the sessions carried out by the participants were with a female ECA, and only in two sessions, the ECA

representing an old male was selected. These obtained percentages have practical implications for a further version of HelPath. As we are assessing how to reduce the size of the App (two of the participants had troubles with the installation, and they had to remove some other unused apps), one option is to remove the old male (each ECA represents around 25 Mb) and leave only the two young female and the young male ECAs.

It is necessary to mention that in addition to assessing the users' acceptability and adherence level, one of the objectives of this exploratory pilot was to detect any bug or malfunction of the App from its use in a real scenario. That was one of the safety reasons to include only individuals with antecedents of suicidal behaviours (ideation, planning or attempt), but not having any of these behaviours recently. Even with the defined exclusion criteria, one participant was detected with a risk of suicide through the Roberts' scale. Until the moment of this detection, after a month of HelPath's use, this person was one of the participants that more used HelPath (15 sessions). Thus, a further pilot with individuals detected with a recent suicidal behaviour is necessary to assess if there are relevant differences in the use, acceptability and adherence to the HelPath's ECAs. A second limitation is the small size of the sample in this pilot. A higher number of participants are needed to confirm or discard the current results about the perception and preferences towards the emotional competence, adherence level and appearance of the ECAs, as well as the use of HelPath.

Conclusions

We described the development and the initial evaluation of an Embodied Conversational Agent used as the main interface of HelPath, a mobile application addressed to prevent and detect suicidality risks. Unlike similar works where ECAs are applied to mental health, the contents of our application are focused in the remote and continuous monitoring as well as the provision of useful CBT-based information/recommendations to people previously detected with any of the suicidal behaviours: ideation, planning or attempt. Although similar applications also include capabilities to detect the risk of suicide, the primary outcome of these works is focused in the prevention and/or treatment of a particular mental health problem such as depression or anxiety [17, 19, 21].

We developed a set of four ECAs representing two young females, one young male, and one old male for the users can select their preferred ECA. A first exploratory pilot was carried out to assess users' perception and preferences regarding the appearance, emotional competence, the promoted level of adherence of the ECA, and the

general use of the HelPath application. The obtained results indicated that the pilot's participants perceived the ECA as emotionally competent, and a positive level of adherence was also reported. However, room for improvement exists in ECA's appearance, which might be influenced by the synthetic voices used in the ECAs. Most of the received suggestions for improvement were related to the artificial-sounding of the ECA's speech. One option to implement in a further evaluation is to offer the option to disable the ECA's speech and display its responses through bubble texts. That would benefit to those users that find synthetic voices as awkward or not easy to understand.

All other received comments for ECA's improvement are currently under consideration to get a new version of HelPath. For example, we are enriching the set of utterances used by the dialogue manager to provide more different phrases when the ECA provides feedback to user's inputs, or when the ECA suggests the next activity to do. The next important step is to use an improved version of HelPath in a pilot involving people detected with a recent suicidal behaviour. As HelPath is one of the components of a computational platform that also includes a web-based application for support the screening and follow up of patients with suicidal behaviour, the deployment of this platform in different health care centres are currently on-going. The use of HelPath as part of this platform will give us the opportunity that different specialists in mental health, after assessment of the patients, will recommend the use of HelPath involving a more significant set of patients. Then, the obtained results reported from the initial exploratory pilot will be complemented and get a better identification of the benefits and cautions in the use of ECAs for individuals with suicidality problems.

Compliance with Ethical Standards

Conflict of Interest   The authors declare that they have no conflict of interest.

Ethical Approval   All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent   Informed consent was obtained from all individual participants included in the study.

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