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Conversational Agent in mHealth to empower people managing the Parkinson's Disease

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Abstract

ONParkinson is an integrated platform that aims to provide smart assistance towards the empowerment of the triad comprised of people with Parkinson's disease, their caregivers and healthcare professionals. Initial studies have shown the importance of providing patients and their caregivers with accessible and credible information to allow them to deal with clinical issues. Over the last two decades, a substantial body of evidence has shown the potential benefits of using embodied conversational agents for health-related purposes. This paper presents the design of a conversational agent, which is being integrated into the ONParkinson's mobile healthcare app, aiming to respond to questions about Parkinson's disease posed by people with Parkinson's disease and their caregivers. A detailed evaluation plan that comprises technological performance, user experience, and health research is also presented.

Keywords: Conversational agent, Chatbot, mHealth, Parkinson's Disease, Self-management, Informal Caregivers, IBM Watson.

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1. Introduction and Background

Among neurological disorders, Parkinson's disease (PD) was the fastest growing in prevalence, disability and mortality in the last two decades [1, 2], with the number of individuals with PD more than doubling to over 6 million [2]. In Portugal, the prevalence of PD has also increased over the last decades, moving from rates around 150/ 100 000 inhabitants to 180/ 100 000 [3, 4]. Its diagnosis, treatment, and management are a complex process that requires continuous monitoring, and the informal caregiver plays an important role. Studies demonstrate that the use of mobile technology facilitates the management of PD, namely in the adherence to medication [5] and in the ability to make informed decisions [6].

Over the last two decades, a substantial body of evidence has shown the potential benefits of using embodied conversational agents for health-related purposes in distinct areas [7, 8]. Conversational agents have been used in healthcare with three primary goals: (i) diagnostic, where agents autonomously conduct clinical interviews with diagnostic purposes; (ii) education and training for health-related aspects of patients' lives; (iii) monitoring/collecting data, where agents are used in telemonitoring and data collection. There is a great variety of conversational agents for healthcare, presenting differences in their purpose, the adopted technology, dialogue management, or input and output modalities. While conversational agents designed to conduct clinical interviews are mostly web-based, the ones designed to train patients in health-related aspects of their lives are usually mobile apps [7, 8]. Another relevant characteristic is the dialogue management type. For instance, agents for diagnostic purposes are task-oriented, while agents for education are mostly no-task oriented. In the last years, major services providers have presented cloud-based solutions (e.g., Assistance from IBM, Lex from Amazon, Hangouts Chat from Google Cloud and Bot Framework from Microsoft Azure) to support the implementation of conversational agents apps. The selection of the service should consider the language to be used by the agent since it uses Natural Processing Language (NPL) techniques to interpret the request done using Natural Language and not all services are available for all languages.

One of the weaknesses in conversational agents for healthcare is the lack of systematic validation of the implemented systems. We consider this may be related to two factors: the implementation of the validation process for healthcare is complex, and there is still no set of metrics, universally accepted by the scientific community, to evaluate the various types of conversational agents. Besides presenting the design of a conversational agent for the ONParkinson's mobile app, this paper describes a plan for the evaluation of three core dimensions: technological performance, user experience, and health research.

2. ONParkinson

A recent systematic review on mHealth apps for PD has shown that despite the increasing number of apps focused on PD, none of them has been designed to support in an integrated way the triad composed of person with PD, caregiver and health professional [6]. The ONParkinson mHealth solution [9, 10] is a platform, in which a mobile app is the main interface, to provide people with PD and their caregivers with self-management capabilities to help them feel empowered in their ability to find strategies in a more informed and collaborative way. The platform also intends to optimise therapy outside the clinical context, with remote support from the health professionals, providing them with an exclusive Web interface, which works as a complement to the mHealth app.

A preliminary user study was conducted to validate the ONParkinson's concept and the potential needs of the triad's users [9]. User tests were carried out with participants from the Portuguese Parkinson's Disease Association (APDPk), including people with PD, caregivers, and health professionals (physiotherapists and speech therapists), in order evaluate the acceptance of the modules and functionalities included in the first version [10]. This initial assessment study allowed us to find that the ONParkinson development was on the right path, with high acceptance by the potential end-users. However, the app should provide reliable information about PD in order to improve user experience and engagement. The FAQ module initially implemented was not enough for the users' needs, and a Questions and Answers system that automatically answers questions asked in natural language about PD was required. Therefore, a conversational agent module has been designed and implemented for the Portuguese Language.

3. Designing the ParkinsonBot

This section presents the design of ParkinsonBot, including its characterisation, the technological approach that was followed and the methodology for building the body of knowledge.

3.1. Characterisation

In order to allow an easier comparison with other conversational agents for healthcare, the ParkinsonBot is classified using the following set of parameters proposed by Laranjo et al. [7]:

- *Type of Technology*: Service deliverable via a mobile application for Android System;
- *Dialogue Management*: Agent-based;
- *Dialogue Initiative*: User (user leads the conversation);
- *Input modality*: Written, spoken (Portuguese Language);
- *Output modality*: Written, spoken (Portuguese Language);
- *Task-oriented*: No (the system is not direct to the short-term achievement of a specific end-goal);
- *Health domain*: Neurology (Parkinson's Disease);
- *Purpose*: Education;
- *Languages support*: Portuguese (see Figure 1).

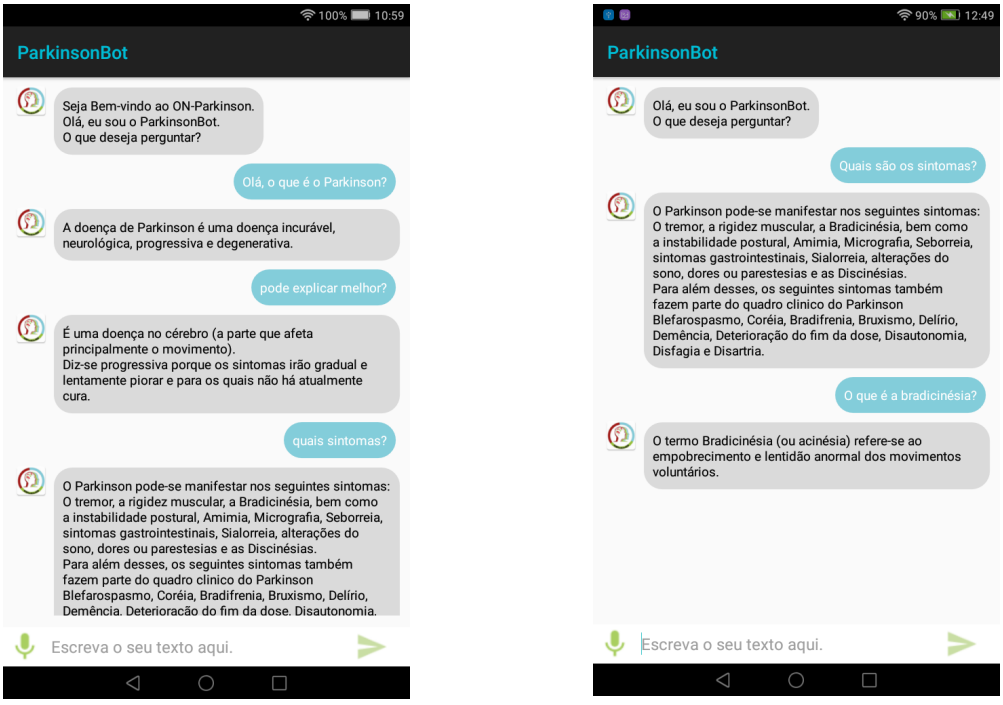

Fig. 1. The ParkinsonBot interface.

3.2. Technological Approach

The ParkinsonBot is a service that was fully integrated into the ONParkinson app. This conversational agent uses three other services in runtime: (i) IBM Watson Assistance for the ChatBot; (ii) Google's Android Text to Speech (TTS API); and (iii) Google's Android Speech to Text API to convert Portuguese speech to text. The first option was to use Watson as the only service provider since its services had already been used with success in health research projects [11, 12] and a recent study appoints Watson as the number one in NPL services [6]. However, it

was noticed that IBM's Speech To Text and Text To Speech services were just available for Portuguese-Brazilian which made us change to Google's Android services.

Regarding the ParkinsonBot's process (see Fig. 2), the Watson Assistant (WA) service uses its API to send the user message to their cloud platform, which processes and returns the answer to our WA service. The user communicates with ParkinsonBot through the ParkinsonBotActivity. It is the activity that controls and manages all the flow of messages and services.

3.3. Building the Body of Knowledge

Results from the initial survey undertaken with thirty-six users from the APDPk [9] allowed us to identify significant information needs from the perspective of both people with PD and caregivers. According to the major topics related to PD and exercises, original texts were developed by a group of health professionals who were asked to write it in a way that may be understood by laypeople, explaining technical terms and giving useful strategies to their daily routine. The iterative design was also considered in order to gradually include more topics and specific information that is important for both people with PD and their caregivers. In this sense, during the development process, focus groups are being used to capture their experience with ParkinsonBot and identify further information to add, according to their concerns and doubts related to PD.

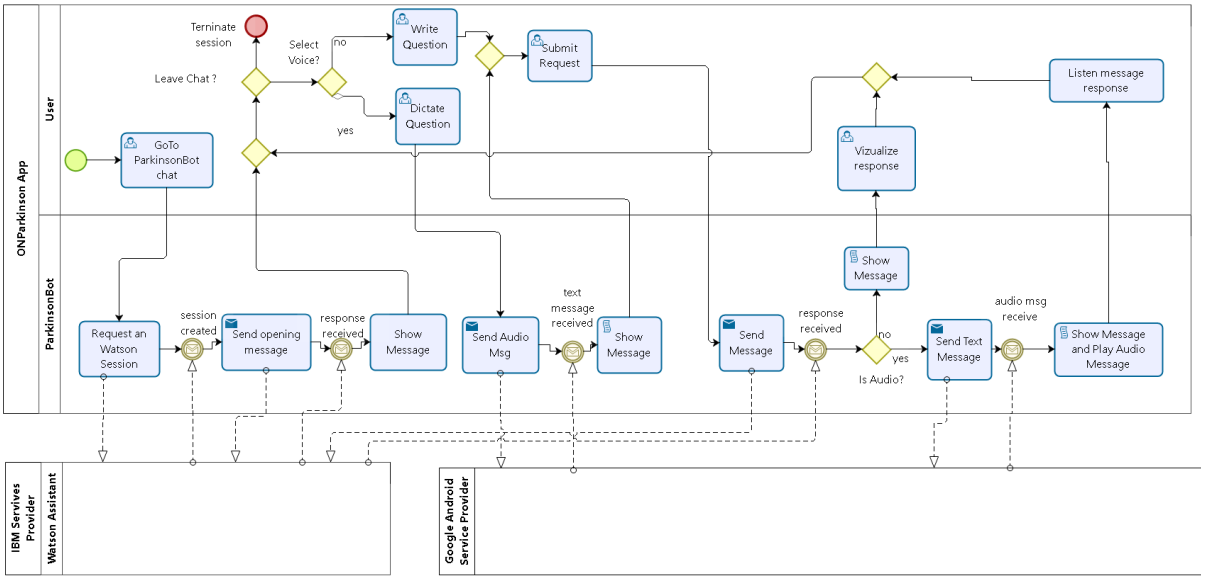

Fig. 2. The Business Process Diagram (BPD) of ParkinsonBot.

4. ParkinsonBot's Evaluation Plan

To our knowledge, there is no standard in the evaluation of conversational agents in healthcare and literature does not present a systematic evaluation of conversational agents for healthcare [7]. We propose an evaluation plan that integrates standards from ChatBots evaluation and web-based and mobile health interventions [13–15]. Therefore, the evaluation of ParkinsonBot comprises three phases executed sequentially, with the last two phases being conducted with people with PD and caregivers recruited in the APDPk. The three phases are described as follows.

1. Technical Performance – It aims to assess the technical properties of the ParkinsonBot as a whole.
2. User Experience – It comprises two phases with two types of assessment in both: (i) an objective user evaluation through the measurement of user interaction data; (ii) a subjective assessment through questionnaires posed to the end-users (overall satisfaction and usability issues).

3. Health Research – It aims to assess the effectiveness of the Bot in terms of health outcomes. It is the more complex and long-term of the three phases, and it will be included in a global evaluation of ONParkinson.

4.1. Technical Performance Evaluation Plan

The technical evaluation of ParkinsonBot aims to evaluate:

(i) Domain Coverage – in which degree the Bot understands the main vocabulary of PD.
(ii) Coherence Response Capacity – if the Bot returns an understandable and relevant response to requests.
(iii) Dialogue Management Capacity – if the Bot can manage the dialogue flow. Four aspects are evaluated:
   a. Detection of initial interaction;
   b. Recovery from missing responses;
   c. Support chaining questions;
   d. Differentiation from chain-question and new questions.

Table 1 details the set of tests and metrics that will be conducted and applied by an experts team in PD.

Table 1. Technical Performance Evaluation Plan.

Characteristic to evaluate	*Test Description*	*Metric*
Domain Coverage	Having as a reference the glossary for PD made available by the experts team in PD, it is asked for each term the question: *What is (term)?* The correction of the response is verified.	*% of terms correctly identified*
Coherence Response Capacity	The initial list of questions is submitted to the Bot and each response is checked to validate if it is comprehensible and relevant.	*% of coherent responses*
Dialog Management Capacity	Conversation scenarios of each type are built and tested. Scenario Types: A. Happy scenario with three independent questions B. Scenario with one chaining question. C. Scenario with two known questions and an unknown question. D. Scenario with not understandable questions (no question, or a foreign language question).	*% of conversations where the Bot detects the start of a conversation correctly.* *% of conversations with chaining questions correctly answered.* *% of conversations with missing response correctly recovered.* *% of non-understandable questions detected.*

4.2. User Experience Evaluation Plan

The first phase will be conducted in a one-day controlled environment following a previously defined screenplay having the goal of finding significant problems; and the second one will occur in the wild in 30 days, in which end-users will be able to use it freely according to their needs. User satisfaction questionnaires, using a 7-Likert scale will be applied at the end of each phase. Objective measures of user interactions with the ParkinsonBot will be obtained through the mobile app. ONParkinson will generate a log file in JSON format for each conversation, gathering the following items: timestamp of each question request, the question, and type of answer. Table 2 summarises the user experience evaluation tests.

4.3. Health Research Evaluation Plan

People with PD and their caregivers (the dyad) will be invited to participate in the study regarding the assessment of the effectiveness of the ONParkinson mHealth app. After receiving a detailed description of the study and giving their written informed consent, participants will be randomly allocated in two groups: the ONParkinson group and the non-ONParkinson group. Dyads allocated to the first group will follow a protocol intervention, including the use of the ParkinsonBot and the modules of exercises and medication management that are included in the app. Dyads allocated to the second one will follow the usual routine of physiotherapy exercises. All participants will be

evaluated before (T0), immediately after (T1), one month after the end of the treatment (T2) and four months after the end of the treatment (T3). All participants will be evaluated by the same team of examiners, who will not know the group to which each participant belongs.

Table 2. User Experience Evaluation Plan.

Source	Characteristic to Evaluate	Metric
Log File	Engagement	Average time of conversation per week. Average time of use per week. Average number of questions per week.
	Effectiveness	% of effective missing responses [to well-formed questions about PD]
	Input/output Preference	% of questions using speech
Questionnaire	• Speech Recognition Satisfaction • Speech Generation Satisfaction • Ease of use • Perception of usefulness • Interaction Satisfaction (how the dialogue is conducted) • Answers quality (vocabulary used and extension) satisfaction • Answers effectiveness satisfaction (user is satisfied with the effectiveness of the Bot answering to questions)	

5. Conclusions and Future Work

This paper described the design of a conversational agent, the ParkinsonBot, which has been integrated into the ONParkinson's mobile healthcare app. The ONParkinson mHealth solution has a mobile app as the main interface, intending to provide people with PD and their caregivers with self-management capabilities in order to help them find solutions in a more informed and collaborative way. The ParkinsonBot was successfully designed to respond to that goal. It aims to empower people managing the disease and its consequences over time. An evaluation plan that comprises technological performance, user experience, and health research, was detailed, which is an essential contribution of the paper since it is an addition to known literature.

Regarding future work, we are initiating the implementation of the evaluation plan, in which the second phase will be important to understand how potential end-users look into the use of ParkinsonBot, while the third phase will have to be very well planned due to its complexity and need to follow participants longitudinally, using a protocol for a long-term study.

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