



**POLITECNICO**  
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# E-health Methods and Applications

## Project Alexa

Team 7

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# 1. Introduction

Approximately one-third of the patients who have suffered a stroke show cognitive deficits, and memory problems are the most common cognitive impairment in this clinical population [1]. In addition, stroke patients affirm that memory impairments are one of the main reasons for the reduction of their quality of life [2].

Despite this high prevalence of post-stroke cognitive impairment, therapeutic possibilities are still limited. Poststroke cognitive decline is mainly found in the speed of mental processing and working memory, which have been suggested to be the functions responsible for the significant reduction in performance of memory tasks [3]. For these reasons, we decided to focus our project on these domains, which will be described in detail in the next paragraph.

Since it has been proven in literature that constant memory training is essential for the recovery of cognitive abilities [4], we created two different exercises using the Alexa Skill Kit.

Moreover, considering that one-quarter of residents in long-term care facilities are stroke survivors [5], we decided to create a scenario in which a smart speaker, in our case Alexa, can be used in healthcare structures such as Assisted Living Facilities or Neurorehabilitation centers. For example, the speaker can be placed in a common room, as in a recreation room, or in the bedrooms of the patients.

Due to the fact that each patient is different and has their own needs and therapy plan, depending for example on the age, etiology or memory deficit extent, the schedule of exercises is tailored to them by their therapist.

For this reason, they can use Alexa for the training when they are asked to perform the test by a reminder that is set by the therapist in the first session, or at any time of the day, to meet their needs.

The scores and the feedbacks of the patients' training can be stored in the system for seven days, so once a week a caregiver or a healthcare assistant can retrieve them for clinical purposes.

## 2. Materials and methods

Every step of our work was based on current literature and on the feedback of an expert in the field, a neuropsychologist working at the "Carlo Besta Neurological Institute" in Milan, who advised us to consult a specific book [10] and specific websites used by cognitive neurorehabilitation specialists.

### 2.1 Exercises for cognitive memory training

For the effective cognitive memory training of post stroke patients, we identified two exercises currently used in common practice, considering the literature and the feasibility of using a voice assistant, Alexa:

The **first exercise** is based on the training of the "working memory", a brain function that maintains a small amount of information used in the execution of cognitive tasks. The exercise consists in asking to repeat the highest or the lowest number in a **series of three numbers**, randomly selected in a range between 0 and 100.

This exercise stimulates the continuous replacing, with speed and precision, of the information already present in the memory with new incoming information. This is not a simple replacement of old information with the new ones: updating involves the processes of activation and inhibition, but in addition requires a constant choice and replacement of the items that need to be kept active [6]. Therefore the exercise requires a continuous and effective activity, in which only a limited amount of information is chosen and kept active among all those entering the system.

Experts also argue that it is very important to have wide variability in the exercises proposed to encourage the development of learning strategies in the patient, so we chose to use a wide range of numbers, in order to guarantee a wide variability.

The **second exercise** consists in listening to a **story**. In neuropsychological rehabilitation practice, in order to recover the ability to remember a passage in brain-damaged patients, this exercise is used to improve the ability to organize, fix and retrieve the information also by means of questions about its content. With the use of the voice assistant, the story is read directly by Alexa. We selected 8 stories taken from the book: "Una palestra per la mente 2" [7] because they are more narrative and used in the practice by neuropsychologist; following the paper of Ruggieri (2005), that suggests to use stories and information from newspapers [8], we selected 4 short stories taken from "La Settimana

Enigmistica" and 3 short stories from "La Repubblica-Cronaca". After listening to the tale, the patient will be asked three related questions. Also in this case we wanted to ensure a wide variability by selecting stories from three different sources, with different length and difficulty in order to avoid repetitiveness and to improve the patient's learning strategies.

As previously stated, since patients could have other associated deficits or other pathologies that would lead to individual clinical cases, there are no "ad hoc" protocols about the memory rehabilitation for post-stroke patients, so we actually chose the exercises described because they are the most frequently used in clinical practice. Moreover, there are no standard treatment plans that guarantee improvements within a set time frame. Each rehabilitation process is personal, therefore it is evaluated and readjusted by the clinician during the rehabilitation. Hence the importance of keeping the results obtained from the training sessions in order to constantly monitor the patient's progress and modulate the treatment plan.

## 2.2 Skill development

We developed the Alexa skill, in order to implement the exercises described, using Alexa Developer with JS as a programming language.

## 3. Skill description

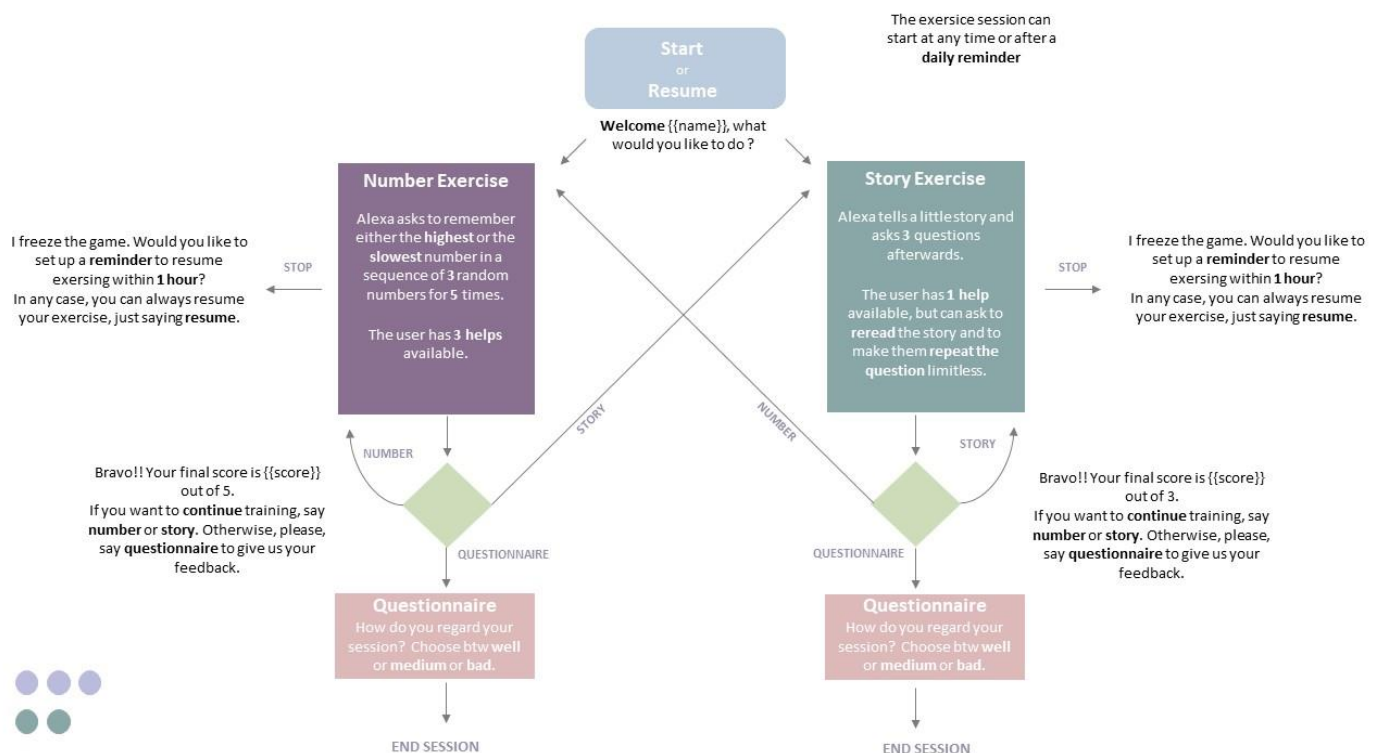


Figure 1 Workflow of the skill

For the first access, our skill, which workflow is shown in Figure 1, is thought to be used by a third person, who is in charge of creating a personal profile of the patient in the Alexa app and to set up a daily reminder (intent "REMINDER", Annex 1) so that the patient does not forget to perform the daily therapy that, as we stated, is fundamental for the cognitive recovery [4]. The reminder could be set at any time the patient prefers, so as to be flexible and give the possibility to choose the best time according to their schedule; in this way the patient can be at ease when starting exercising.

When the patient opens the skill, Alexa welcomes them with their name and then the patient can choose between the two options of the exercises: "number exercise" or "story exercise".

Before starting the exercise, Alexa gives a brief introduction and explanation about the rules and the possibility of having "hints" (intent "INSTRUCTIONS", Annex 1). We decided not to take them for granted, since our target patients have memory injury.

The "number exercise" has 5 questions. Each time the patient is asked to memorize the highest or the lowest number of a series of 3 random numbers, ranging from 0 to 100. After listening to the series the patient has to answer. For each correct answer the patient gets a point that is added to other correct answers, totalizing a score. If the answer is wrong, there are no points. The patient can ask 3 times out of 5 for help, which consists of repeating the series and the respective question.

At the end of the exercise, the final score is given to the patient. It is also compared with the previous score, so that the patient knows if they are getting better, if they have the same result or they are encouraged to constantly train to improve their capabilities.

For what concerns the "story exercise", Alexa reads a short story that has 3 questions related. It works in the same way as the "number exercise": the patient gets a point for each correct answer, 0 points for a wrong answer. In this case the user can ask Alexa to read the story or the questions any time they want, but they can ask only for one "help", which in this exercise, consists of a hint to answer one question.

Also in this case the score is announced at the end of the exercise compared with the previous result.

In both exercises, if the patient admits they do not know the answer (intent "DONOTKNOW", Annex 1), Alexa encourages them not to give up and reminds them about the possibility of asking for hints. In addition, in case the patient has some doubts, they can always ask Alexa to repeat the instructions that were given at the start of the exercise.

There is also the possibility to stop the exercise session. In this case, the patient is asked to set a reminder for the next hour to remember to restart their daily training, but they can resume the exercise whenever they want by asking Alexa.

When the exercise is resumed, Alexa remembers which exercise was not completed, the related score and suggests the patient to retry the same exercise or to challenge themselves with the other type.

Additionally, by consulting the neuropsychologist from the "Carlo Besta Neurological Institute", we also found out that it is really important to have a "metacognitive" part at the end of the session; in other words, it is fundamental to ask the patient for a quantitative feedback about their performance. As a matter of fact, at exercise-session completed, the patient is asked what they think about their performance. The question addressed is " ... " with multichoice answers (... - ... - .. ).

We decide to address only one simple question, in order not to further stress the patient and so to always get their feedback. The multichoice answers (... - ... - .. ) refers to a scale from 0 to 3, to have quantitative information.

This feedback, along with the score of the patients' daily activity, can be retrieved by asking Alexa for the weekly report (intent "REPORT", Annex 1).

Finally, we also decided to implement a funnier aspect of Alexa that, if asked, can entertain the audience with Christmas jokes (intent "JOKES", Annex 1).

## 4. Future Developments

For future developments, it would be useful to have a cloud service with an online database in which all the patients' answers and questionnaires are saved, so that they could be used for clinical purposes not only week by week but also for longer periods.

Another implementation could be the creation of different levels of exercises, with increasing difficulty so that the test could be suitable for different degrees of cognitive impairment and customized for each patient. In particular, by tracking down the progress, if the patient succeeds in obtaining the maximum result for more days in a row, they "unlock" more complex stories or series of numbers. Another way to raise the level could be by lowering or eliminating the "hints" and the other options, such as the possibility of reading the story and the series multiple times.

Moreover, new types of exercises could be implemented such as a series of numbers that should be repeated forwards and backwards by the patient, as validated in literature [9], exercises similar to crossword puzzles [10] and words association exercises [7].

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**Additional** Intents callable during the exercise session



Alexa explains how the exercises **work** and the options the user has.



Alexa encourages the user not to give up, remember them it might **help**.



Alexa tells a funny **Christmas** joke.

\* These Intents are thought to be used by a third person.



Alexa set a **daily reminder** for daily exercise **at the time** the user decides to



Alexa reports the user's **weekly activity**, specifying for each day the **exercises done** with **respective scores** and **feedback** by the questionnaire.