

Technology Acceptance of an Online Speech and Language Assessment Application for Stroke Patients - the Medical Caregivers' Viewpoints

Awais Ahmad
Computer and Systems Science
Östersund, Sweden
e-mail: awais.ahmad@miun.se

Karin Ahlin
Computer and Systems Science
Östersund, Sweden
e-mail: Karin.ahlin@miun.se

Peter Mozellius
Computer and Systems Science
Östersund, Sweden
e-mail: Peter.mozellius@miun.se

Abstract— Stroke is a globally increasing disease and speech and language deficiencies are common in stroke survivors. To facilitate medical caregivers in their professional work and to improve patients' quality of life, technology can play an important role. However, the use and acceptance of technology are uncertain, and more research is needed in this direction. This study evaluates the technology acceptance and adoption of an online speech and language assessment application. The evaluation focused Design Science Research strategy was adopted for that purpose. Two physiotherapists, one occupational therapist and three speech therapists participated in the study. The Unified Theory of Acceptance and Use of Technology (UTAUT) was used as the theoretical base for interview questions formation and data analysis. The study findings show that the suggested application is useful and easy to use; however, it should be more synchronised with speech therapists' daily work routines. The speech therapists stressed that functionalities of the application should be designed in close collaboration with them, and it should be compatible with the already existing systems and services in place. Due to the impairments after stroke, the patients have some specific preferences for software and hardware such as a tablet with touch pen is the preferred hardware. Additionally, the interface should have bigger text fonts and pictures, and highly contrastive colours in the graphics should be used for patients' convenience. The user's privacy and security, patient's current health, and their previous knowledge and experience about technology were also found important determinants for intention to use the given technology.

Keywords—*Technology acceptance; Speech and language relearning; Unified Theory of Acceptance and Use of Technology (UTAUT); eHealth; Stroke.*

I. INTRODUCTION

In the rapidly growing percentage of older adults, age-related chronic diseases increase [1]. Stroke is one of those diseases where stroke survivors often suffer from both physical and mental impairments [2]. The impairments after stroke have a serious impact on patients' overall daily life quality and often a patient's friends and relatives are affected [3][4]. Stroke impairments and rehabilitation after stroke can be divided into motoric, cognitive and speech disabilities [5]. This study has a focus on speech impairments and the use of

a technology-enhanced system to assess the speech and language impairment, and to find a relevant rehabilitation plan.

After stroke patients' ability to read, write, speak and listen can be decreased to different degrees depending on how the stroke has affected the brain [6]. Stroke patients' social and professional life is often severely affected, which can lead to an isolated and depressed state of mind. An important part of a successful rehabilitation process is to early assess the speech and language impairments, and to start the relearning as soon as possible. Speech therapists often work with pen-and-paper based assessment systems where calculating results, storing statistics, and measuring progress are time-consuming tasks. This study evaluates a prototype of the digitalisation of the pen-and-paper based language assessment system 'A-ning'.

Aning is a Swedish word that could be translated to English as 'Clue', symbolising the important idea of getting a clue of which speech and language relearning activities the actual patient needs. The A-ning system has at least three user roles, stroke patients, speech therapists and health administrators. This first evaluation of the digital prototype only involves the speech therapist perspective, and that this must be followed up later by tests with the other user groups. Three speech therapists with a long professional career participated in the tests for this study, where interview questions and data analysis were based on the Unified Theory of Acceptance and Use of Technology (UTAUT) [7].

A. Aim

Despite the fact that several advanced and sophisticated technologies are available in the health sector, the use and acceptance of these technologies are doubtful and more research is needed to find the critical factors that might affect technology acceptance [8]–[11]. UTAUT model [12] has been widely used in research to evaluate the effectiveness and adoption of technology-enhanced systems [11][13][14]. This study is aimed to access and evaluate the technology acceptances of an eHealth application by using the UTAUT as a theoretical model.

The addressed research question was:

What is the technology acceptance of a speech and language assessment application from medical caregivers' viewpoint?

The remaining paper is structured as follows. In Section II, the UTAUT theory is presented as the theoretical framework of this study. An overview of the Speech and Language Assessment Application (A-ning) is given in Section III. Section IV describes the adopted methodology for this study, while the study results and the discussion about those results are presented in Sections V and VI respectively. Finally, The study conclusion and recommendations for future work are presented in Section VII.

II. THEORETICAL FRAMEWORK: UNIFIED THEORY OF ACCEPTANCE AND USE OF TECHNOLOGY (UTAUT)

The UTAUT model was designed to assess the user behaviour and intention to use technology [12]. It is a synthesis of eight different theories and models that were previously designed for technology acceptance including the Technology Acceptance Model (TAM), a widely acknowledged model to identify the intention to use the technology [11][13][15].

After comparing and synthesizing those eight models, Venkatesh et al. [12] suggested that the intention to use technology depends upon four basic factors: performance expectancy, effort expectancy, social influence and facilitating conditions. Performance expectancy is explained in TAM as “perceived usefulness”, and effort expectancy is stated as “ease of use” in TAM. In other words, the UTAUT model can be seen as an extension of TAM as it adds two extra factors, social influence and facilitating conditions. Several studies highlighted that social influence such as the role of important others, and facilitating conditions like education and training are important for technology acceptance [6][16]–[18]. Therefore, the UTAUT model was preferred as the theoretical framework for this study. The UTAUT model suggests the following four technology acceptance elements.

A. Performance expectancy

Venkatesh et al. [12] defined performance expectancy as “the degree to which an individual believes that using the system will help him or her to attain gains in job performance” [12]. It is considered an important determinant of intention to use technology in many different studies [7]. Venkatesh et al. [12] highlight, the user should have a firm belief that the system will improve his/her productivity and performance, speed up the work tasks and it will make the work easier.

B. Effort expectancy

Effort expectancy describes the user’s belief in the ease of use of the system. Venkatesh et al. [12] stress that

learning to operate the new system should be easy and quick, the use of the system should be effortless, and the interaction with the system should be understandable and clear. The system should take less time and effort to perform mechanical operations such as data input [7].

C. Social influence

Venkatesh et al. [12] described social influence as “The degree to which an individual perceives that important others believe he or she should use the new system”. The beliefs of the other influential and important people have a significant effect on the intention of use of the system. In an organization, the viewpoints of co-workers, supervisors and senior management play an important role in the acceptance of a technology-enhanced system.

D. Facilitating conditions

Venkatesh et al. [12] defined facilitating conditions as “The degree to which an individual believes that an organizational and technical infrastructure exists to support the use of the system”. The new system should be compatible and synchronized with the existing work routines and work style of the user. Guidance, clear instructions to use, and personalized support are the essential determinants for technology acceptance [7].

III. SPEECH AND LANGUAGE ASSESSMENT APPLICATION (A-NING) OVERVIEW

Speech and language relearning starts with an initial test of the patient’s communication loss after stroke; the test is called A-ning [19]. Despite the test is being developed a long time ago (in 1995), it is still the most used and comprehensive test for language impairments in Sweden [20]. The test is a standardised process conducted by speech therapists, and it consists of different assessment tasks. For example, the patient is asked to look at an image (see Figure 1) of an outdoor restaurant and describe the different activities there.



Figure 1. An example of a Patient’s task

During a session with the patient, the speech therapist gives some points from 0 to 5 on each task. Those points are then calculated according to different language categories and the average of all those categories is calculated to summarize the assessment, which is quite a time taking process. Figure 2 presents the manual evaluation after the test.

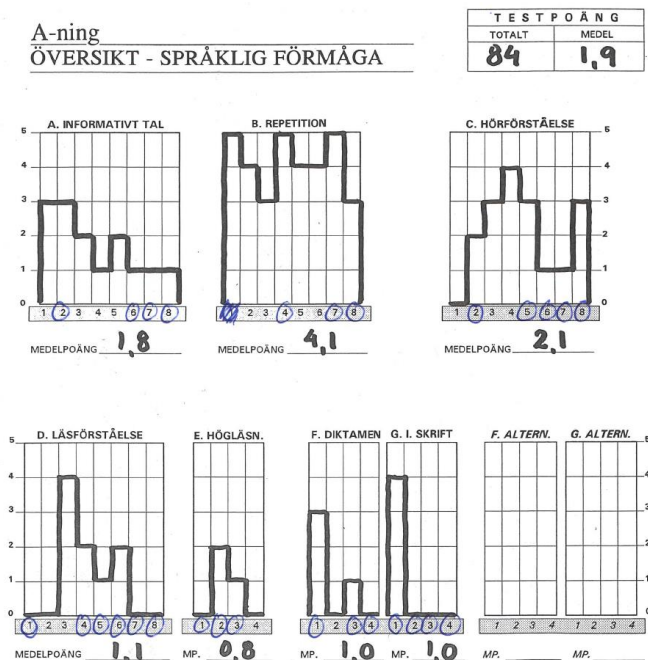


Figure 2. Manual and paper-pen based evaluation

The speech therapists (Participants 1-3, Table 1) emphasised the need of converting this old paper-pen system to an online application. The application was co-created in close cooperation with speech therapists. As presented in Figure 3, after the session with the patient, the application presents auto-generated graphs.

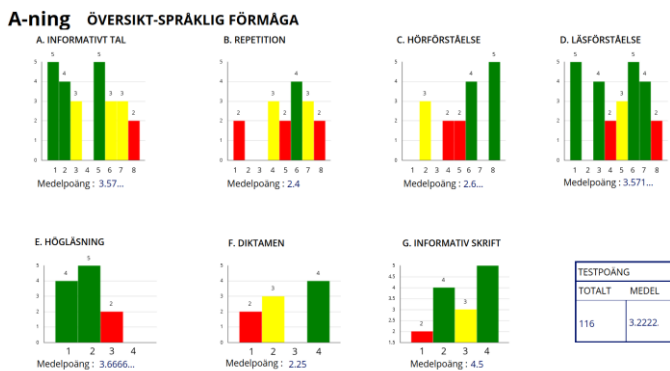


Figure 3. Digital Speech and language Evaluation System

Each graph presents a set of exercises that are related to a specific category. Different colours in the graphs present a

patient's deficiency level; the green colour presents minor impairments, the yellow colour presents mild impairments and the red colour presents some major impairments.

IV. METHOD

To explore and evaluate the technology acceptance of an online aphasia assessment application, the Evaluation Focused Design Science Research strategy was followed [21]. The assessment application was developed in collaboration with speech therapists at regional municipality rehabilitation. Six therapists participated in the study. Their location and years of experience in speech and language rehabilitation are presented in the following Table 1.

TABLE I. STUDY PARTICIPANTS

Participants	Professional role	Region	Years of experience
Participant 1	Speech therapist #1	Stockholm	25
Participant 2	Speech therapist #2	Mid Sweden Region	4
Participant 3	Speech therapist #3	Mid Sweden Region	5
Participant 5	Occupational Therapist	Mid Sweden Region	5
Participant 6	Physiotherapist #1	Mid Sweden Region	8
Participant 7	Physiotherapist #2	Mid Sweden Region	3

Participants 4-6 work as the mobile stroke-rehabilitation team at the regional hospital. They offer rehabilitation services at the patient's home for those who are living within the 70 Km range from the hospital. The main reason to involve these participants was to explore the effect of social influence on technology acceptance.

Following design science, the evaluation is conducted in two steps. First, the artefact was demonstrated for an initial evaluation and a detailed evaluation was conducted in the next step.

A. Demonstrate artefact

The purpose of this activity was to demonstrate and test the artefact in one case. In this activity, the application was tested and evaluated for technology acceptance with only one speech therapist (Participant 2). This type of initial demonstration gives us an idea about how well the artefact addresses the identified problem in one scenario. Johannesson and Perjons [21] argue, if an artefact performs

well in one case, there are some good possibilities that it might perform the same in many other cases.

Figure 4 presents an overview of the artefact demonstration activity. The activity was carried out in two sub-activities. First, a test case was designed that contains five tasks followed by some interview questions (see APPENDIX I). The interview questions were developed using UTAUT as base knowledge [7][12].

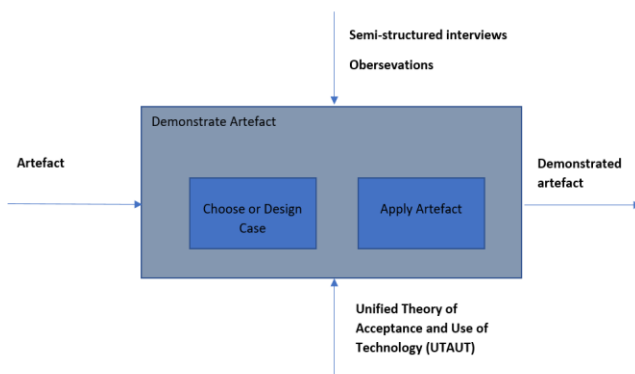


Figure 4. Demonstrate artefacts Activity

The activity was performed at the local municipality rehabilitation centre, one speech therapist (Participant 2) and all the three researchers participated in this activity. After the session, the researchers discussed and analysed the data, and found that the application was effective for aphasia assessment; however, some changes and additional functions were suggested. The application was updated by implementing the suggested alterations and it was ready for a detailed evaluation.

B. Evaluate artefacts

After demonstrating the artefact, the next step was to make a detailed evaluation of the artefact. As suggested by Johannesson and Perjons [21], this activity aimed to evaluate whether the developed artefact solves the defined research problem or not. As presented in Figure 5, the activity was conducted in three sub-activities; analyse the context, select goals, and finally conduct the evaluation. The old aphasia evaluation system was paper-pen based while the new system is technology-enhanced; therefore, technology acceptance was analysed as a context and exploring technology acceptance of the new system was highlighted as an important goal for conducting the evaluation. As described in the artefact demonstration activity, UTAUT was used as theoretical base knowledge for data collection and analysis.

Four sessions were conducted with all three speech therapists. In both demonstration and evaluation activities, the same interview questions and evaluation tasks were used (See APPENDIX I). Because of the Covid-19, some participants were working from home, therefore, three sessions were conducted at the municipality rehabilitation centre, where two researchers participated online and only

one researcher conducted the session at the rehabilitation centre. However, the last interview was entirely online where all the study participants and the researchers participated online. For data collection and recordings, the Zoom Meetings Platform was used [22].

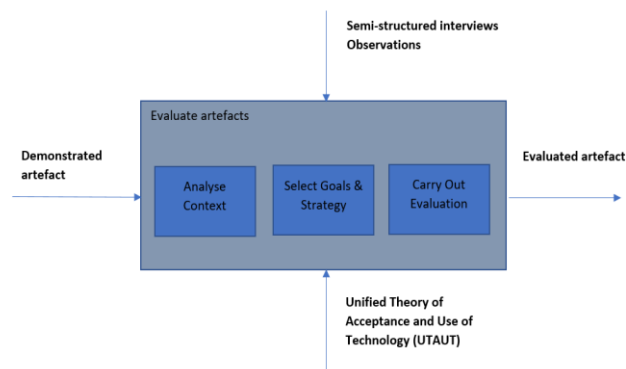


Figure 5. Evaluate artefacts Activity

Deductive thematic analysis was performed for data analysis [23]. First, the transcripts and audio recording were thoroughly examined and initial codes that were relevant to technology acceptance of the artefact were selected. The defined codes were then categorised according to the determinant factors of the UTAUT model as initial themes. Thereafter, the important findings that were relevant to answer the research question were identified and presented in the findings section.

C. Ethical considerations

The rules and regulations from the Swedish Research Council (Codex) were followed for ethical considerations [24]. Before the interviews started, all the participants were informed that they could refuse to answer any question and cancel the interview at any time (before or during the interview). The privacy and anonymity of the study participants are also important to consider in research ethics

where people are involved [25]. The interviews were recorded with the participants’ permission and their anonymity was ensured. The interviews recordings were stored in the secure database at the university that is only accessible by the relevant study researchers.

V. RESULTS

To evaluate the technology acceptance, the results were thematically analysed and categorized according to the UTAUT model’s determinants: performance expectancy, effort expectancy, social influence and facilitating conditions. However, these categories were not enough to cover the contents of the interviews. Therefore, privacy and security, and previous knowledge and experience about technology were added as extra categories.

A. Performance expectancy

This category explains the perceived usefulness of the online assessment application. All the study participants mentioned that the online application is beneficial for speech and language assessment (Participants 1-3). The automatically generated points-based evaluation of language impairment was the most valued function in the application. The paper-pen based and manual assessment involves several calculations that take a lot of time after the assessment session with patients (Participants 1, 2). Speech therapist 3 described, *“The manual evaluation system was time taking and boring; it takes 40 minutes for me to conclude the evaluation and to transfer it to the hospital journal system”*. Speech therapist 1 mentioned, *“The assessment tasks and exercises with the patients are performed in a different order and the final evaluation is categorized in a totally different sequence of exercises. Therefore, it is quite hectic to rearrange everything after the session with the patient and to calculate every point in a different sequence.”* Figure 2 gives an overview of the paper-pen based evaluation.

Based on the speech therapist's input during a session with the patient, the new calculation system diagnoses speech and language deficiency automatically. Participant 3 described that the new system will help her with point-based diagnosis, and to save data digitally. Figure 3 demonstrate the new digital assessment system. All the speech therapists acknowledged the usefulness of these coloured graphs as they make it easy to discuss with patients their health condition (Participant 1-3). The patients will get a better idea of their impairments in different language categories and it will be easy for speech therapists to highlight in which category the patients need to put some more effort (Participant 3).

B. Effort expectancy

This category explores the ease of use of the software application. A continuation of the performance expectancy is the new calculation system, where participants 1-3 discussed the necessity of individualizing the traffic light metaphor as well as interpreting it. There is a need for individualizing the speech training, both relating to the patient's current health condition and goal with the speech training. Based on the latter, the system should allow follow-ups and comparisons between the various test occasions. The speech therapists 1- 2 declared that they hoped for the patient to improve, shown in the statistics, and that the system should help them to increase the degree of difficulty at each test occasion. The ultimate goal should be to get a detailed assessment system that could find more linguistic defects. The speech therapists 1 - 2 declared that such a system would take at least five years to develop, but as brought up by Participant 1, there are several words and expressions in A-ning that today are obsolete and difficult to understand for younger patients, and for patients with a foreign background. An alternative is to update the existing A-ning system, or as suggested by Participants 2 and 3, the

digitalization could be carried out based on A-ning, but with the possibility to replace the A-ning tests with some other test system in the future.

Aforementioned is that the statistics are the obvious gain of digitalising the assessment. To gain more efficiency should there be an overall workflow, with a starting point and the next assignment showing up, without interference. Participants 1-2 emphasize that they should be the ones choosing the assignments and that the order should be shown on an overview. Emphasized by all participants are that there should be possibilities to add individual notes, both for each assignment and on a general level, e.g., when an assessment is completed. Another important aspect of the system is that each category should be marked with one colour, improving the possibilities to interpret the test results. One suggestion from Participant 1 -2 is therefore to create folders with descriptive headlines, where assignments from each category could be stored

C. Social influence

This category explains the other co-workers' views about the usefulness of the system. The viewpoints of speech therapists' colleagues (Participants 4-6) were used to assess the social influence. Moreover, speech therapist 2 discussed the usefulness of the applications with their fellow therapists; all the co-workers acknowledged the usefulness and a positive intention to use the assessment application (Participant 2). Stroke patients feel comfortable and motivated by getting treatment in their home environment and living independently (Participants 4-6). The rehabilitation process is faster and more effective when the patients are at home with their significant others (Participants 3, 4-6). Since the application provides the possibility of online sessions, the application will be useful for the patients as well as for the speech therapists (Participant 1).

D. Facilitating conditions

This category discusses the availability of facilitating conditions such as technical infrastructure, education and training about the application functions, and personal support for the system. The requirements on technical infrastructure are several and focus on not solely converting the assessment from a paper-based assessment to a digital system. One example is the participants' emphasis on having different views for the patient and the speech therapist on every given occasion. Therefore, the patient's screen should show, e.g., one image, while the speech therapist should see several images and pick one for the patient. Another aspect is the possibility to change the size of the patient's image to offer him/her the best possible resolution.

One part of the assessment is for the patient to write, e.g., what is shown on the screen. Therefore, a touch pen is necessary, preferable on a tablet (Participant 1 - 3). The tablet's size should allow both the patient and speech therapist to write on it. On occasion, the speech therapist needs to give written instructions, adding requirements on immediate digital interaction. Another patient assignment describes what is shown on the screen and creates a story,

preferably recorded. The recording also needs to be played for further evaluation by the speech therapist.

Previously described is that stroke patients often suffer from brain fatigue, offering small time slots of total energy. Therefore, there is a need to save the solved assignments and continue at another session not related to a specific speech therapist. Related to partly finished or fully finished assessment is the integration to any journal system. Participant 3 emphasizes the importance of this requirement, describing that it takes 40 minutes of administration to cover this manually.

E. Privacy and security

Trust on privacy and security of the users' data was also a matter of concern for the participants. One part of privacy and security is that other speech therapists should be able to see the results from one assessment to create efficiency in the flow of patients. Still, the patient's privacy and security should be in focus for the system. Somewhat contradictory to the patient's privacy and security is the involvement of relatives or other secondary users. The secondary users are essential, depending on the patient's condition and the wish of distance use. They should be able to help the patient, still not affecting the results of the assessment.

F. Previous knowledge and experience

The user's previous knowledge and experience about related technologies was another important factor for technology acceptance. During the interviews, it was observed that the participants who have previously used relearning applications in their work, showed more interest in using the suggested application. The users' participation in the design and development also enhance their knowledge and interest in the given technology. The speech therapist (Participant 2) who was involved throughout the process of the application's co-creation showed the most enthusiasm and intention to use the application. However, the speech therapist (Participant 3) who was involved only in the evaluation phase, showed the least interest in using the application.

VI. DISCUSSION

The study aimed to explore the technology acceptance of the speech and language assessment application from medical caregivers' viewpoints. Since the medical caregivers (speech therapists in the study context) play an important role in the patient's recovery and relearning, their viewpoints and participation in the system development are important [26]. The same phenomena are observed in this study; the participants with the most participation showed the most intention to use the application. The technology acceptance also depends upon the expected benefits of using the system. The unawareness of the potential benefits of a given technology and a fear to use that technology negatively affect the medical caregivers' performance expectancy [27]. Therefore, continuous technical support and training are of great importance.

There are several options while creating a digital version of the A-ning assessment system. One is to convert the

paper-based system to a digital version, adding the feature of creating better possibilities for the speech therapist's to use statistics, both for individual patient's or synthesising statics for specific categories of patients or on an assignment level. The prototype adds such features, improving parts of the work for the speech therapists. Another option is to, still based on the involvement of the speech therapists, create an online system, separating features for the speech therapists and the patient. Examples are immediate written interaction between the speech therapists and the patient's screen or showing different images. The development could be done in steps, where one initial step could be integrations to various journal systems, offering immediate efficiency for the speech therapist. Creating an online system relies on various technical solutions, like recording or writing on one screen and reading on another. The interaction of being in the same room simultaneously needs to be replaced by other interactions and be based on the patient's varying condition.

A-ning is the most frequently used and comprehensive test for speech and language impairment in Sweden, and all participants find the system to be of high quality. However, natural languages like Swedish are entities that change over time and the test vocabulary involves some words that today must be classified as obsolete. Important for the younger generation of patients in a country where 20% of the population have a foreign origin. In the same way, as a thesaurus needs continuous updating, a language test system also needs updating. This looks like the most realistic alternative for the moment, since the development of a new test system would be both costly and time-consuming. Authors find the analogue A-ning system to be a thorough and high-quality test system, and a good foundation for further digitalisation. Some obvious contributions to the language relearning process in a further digitalised version of the system would be features for statistics and for measuring relearning progression.

VII. CONCLUSION

The study explored the acceptance of an online speech and language assessment application. The factors that might affect the adoption and use of technology were also discussed in the study. The online evaluation seems more effective and efficient than the traditional manual system for speech therapists and it enables independent living for the patients. To enhance the performance expectancy, the potential users (speech therapists) should be involved throughout the application development process and all the application functionalities should be comprehensively discussed with them. The intention to use the application depends upon patients' medical condition, active users' participation in the application development, trust about privacy and security of personal data, and providing users with proper education and training about the system.

This evaluation was carried out with a speech therapist and caregiver perspective, which is an important part of the process. The next important step is to get the patient perspective, in an evaluation that preferably also should involve some patients' relatives and friends. Furthermore, the multi-stakeholder approach should include administrative

staff at health centres and hospitals to get their view on statistical features and security aspects. Finally, what seems like the most valuable contribution of a further digitalised system would be to implement more features for test result statistics, and for visualisation of relearning progression.

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APPENDIX 1

A. Evaluation Tasks of A-ning application

1) Task 1

Preplanning for a new patient

- Create a new patient by giving information:
- First name: Awais
- Last Name: Ahmad
- Personal no. : 8111150000
- Speech therapist Name: Tove
- Select the exercises

2) Task 2

Performing the exercises A2, A6, A7, A8

- Complete the tasks for all the
- Select an exercise
- Write some comments in the comments box
- Give some points

3) Task 3

Describing the evaluation

- Select the graph sign from the main page
- Describe the evaluation for different categories
- Describe the overall aphasia evaluation

4) Task 4

Changing the selected exercises during an ongoing evaluation

- Select some exercises, which are not selected
- Deselect some exercises, which are selected
- Update the Information

5) Task 5

- Resuming a previously started evaluation

B. Technology acceptance Interview questions

1) Question 1.

How easy-to-use was the system as compared to the old system?

2) Question 2

Which feature was difficult to use and what was easy to use?

3) Question 3

What are your recommendations to improve the interface?

4) Question 4

How do you see the usefulness of this system for the patients and other speech therapists?

5) Question 5

What help do you need for the use of this system in terms of:

- Infrastructure
- Education/training