

Technology-enhanced Speech and Language Relearning for Stroke Patients

Understanding the users and their needs for technology acceptance

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Abstract

Stroke is a rapidly increasing disease worldwide, and speech and language impairments are common in stroke patients. A patient's ability to speak, listen, read and write is reduced after stroke which affects the patient's independently living and quality of life. After an initial evaluation at the hospital, the stroke survivors are referred to the stroke rehabilitation centre where the speech therapists assist them in their challenging and long journey towards speech and language relearning. To enhance the patient's quality of life and to facilitate the speech therapists, technology-enhanced systems can play an important role. However, the currently used software applications such as online speech and language relearning applications are not specifically designed after the user's need, and the user's participation and empowerment are compromised. Medical caregivers and stroke patients are the main stakeholders and potential users of these software applications. Therefore, this study is aimed to understand the medical caregivers and the stroke patients' needs for technology-enhanced speech and language relearning from medical caregivers' viewpoint.

Design science research strategy was adopted to create, implement and evaluate the artefact. Some important stakeholders such as speech therapists, a stroke specialist doctor, information and technology professionals and one stroke survivor participated in this study. Following the speech therapist's expert opinion, an application for speech and language assessment was developed as an artefact. The application was then evaluated for technology acceptance with the speech therapists. The Unified Theory of Acceptance and Use of Technology (UTAUT) was used as the theoretical foundation for making the interview questions and data analysis.

The user's requirements for software application differ from one patient to another depending upon the patient's overall health after stroke, their age, social life, the level of speech and language loss, and previous experience with technology use. Stroke is common in adults and adults like to participate in designing their relearning process; therefore, adults should be involved in deciding the learning objectives, and adult learning principles are helpful to understate their needs for speech and language relearning. Due to impaired physical and cognitive conditions, the patients need a bigger interface with larger fonts and pictures and more constructive colours than usual. Tablets with touch pens are preferred hardware. The speech therapist should have the possibility to change the exercises runtime according to the patient's abilities and stamina to do the exercises.

The technology acceptance evaluation showed that the developed application was easy to use and efficient for speech therapists. The study participants also highlighted some critical issues for better usability and technology acceptance. The application should be synchronized with speech therapists' existing workflow and routines, and it should directly be connected to the hospital records system so that the patients' data can easily be transferred to their journals.

The role of facilitating conditions such as proper education and training about the system, and personalised support is also important in technology acceptance. The user's trust in the system's security and privacy and their personal integrity were also highlighted as main determinants for technology adoption and use. To achieve better coherence between the users and technology, all the tasks/exercises and sub-tasks in the application should be designed in close collaboration with speech therapists and stroke patients. Due to the Covid-19 pandemic, only one stroke survivor was interviewed in this study. However, the patients' perspective is of utmost importance, and in future research, they will be involved in the design and development of such technology-enhanced systems.

Keywords: *eHealth, Stroke Rehabilitation, Speech and Language Relearning, Adult Learning, Technology-enhanced Systems, Technology Acceptance*

LIST OF RESEARCH ARTICLES

- I. **Ahmad, A.** & Mozelius, P. (2020). On the Importance of Tailor-made Speech Relearning Software for Stroke Rehabilitation. In Proceedings of the Seventh International Conference on Information and Communication Technologies for Ageing Well and e-Health - Volume 1: ICT4AWE.. pp. 176--179.
- II. **Ahmad, A.** , Mozelius, P. & Ahlin, K. (2021). Speech and Language Relearning for Stroke Patients- Understanding Users' needs for Technology Enhancement. In Proceedings of Thirteenth International Conference on eHealth, Telemedicine, and Social Medicine (eTELEMED 2021), Nice, France, July 18, 2021
- III. **Ahmad, A.** , Mozelius, P. & Ahlin, K. (2021). Factors Influencing Acceptance of Technology-enhanced Speech and Language Relearning for Stroke Survivors – A Systematic Review. In Proceedings of the 7th International Conference on e-Society, e-Learning and e-Technologies (ICSLT2021) Portsmouth, United Kingdom, June 10-12, 2021
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List of abbreviations

IS	Information Systems
ICT	Information and Communication Technology
DSR	Design Science Research
SLR	Speech and Language Relearning
TES	Technology-Enhanced Systems
UCD	User-Centred Design
UTAUT	Unified Theory of Acceptance and Use of Technology

1 Introduction

Stroke is a major cause of death and chronic impairments in adults (Guo et al., 2021). According to the World Health Organization (WHO), about 15 million people around the world suffer from stroke and potentially five million of them have long-term or permanent disabilities (Freund et al., 2021). The stroke occurs because of a disturbance in blood flow to the brain, resulting in serious damage to brain function. This damage causes different types of physical and mental disabilities in the patient (Tousignant et al., 2018). These disabilities severely affect the daily routine life of a stroke survivor and the patient tends to have compromised quality of life and independent living (Palmcrantz et al., 2017).

Post-stroke disabilities are classified into motoric, cognitive and speech impairments (Ahmad et al., 2019a). This study discussed the potential use of technology and its implications in speech and language relearning for stroke survivors. Speech and language deficiencies are further divided into four basic communication pillars: read, write, listen and speak (Tousignant et al., 2018). Due to the decreased communication ability, the patients have to face some serious difficulties in their daily life. Their social and professional life is severely affected and they often feel depressed, lonely, and disconnected from society (Ahlin et al., 2019). To overcome these problems, the speech and language relearning process should be started as soon as possible. Early interventions not only speed up the relearning process but also have good effects on patients overall mental health (Kesav et al., 2017).

After stroke, intensive and long term rehabilitation is needed for speech and language relearning that includes different types of speech therapies and physical exercises (Palmcrantz et al., 2017). The role of a speech therapist is very important in the patient's recovery (Brady et al., 2016). After initial treatment at the hospital, disabilities regarding speech and language are referred to speech therapists at the rehabilitation centre. The speech therapists then make a comprehensive plan for the patient's rehabilitation and relearning. These therapists require a huge amount of financial and human resources at rehabilitation centres (Ahmad and Mozelius, 2020). However, these resources are not enough for the swiftly increasing stroke patients, and alternative and innovative interventions should be explored in speech and language relearning (Palmcrantz et al., 2017).

A compromised independent living is also a problem with traditional speech therapies. The stroke survivors have to stay at hospitals and rehabilitation centres where they are dependent on the medical staff. Even when they return home, they are dependent on their friends and family to perform their daily routine tasks (Freund et al., 2021). Several studies stressed that living independently in their home environment not only speed up the patient's recovery but also improve the quality of life of the patient and their significant others (Ahmad et al., 2019a; Christophorou et al., 2016; Freund et al., 2021). Technology-enhanced systems (TES) can be useful in this context. The TES might decrease speech therapists' workload and facilitate stroke patients' speech and language relearning (Ahmad et al., 2020); therefore, both stroke patients and speech therapists are the main beneficiaries and potential users of intended TES.

The speech therapists conduct an initial assessment test of the patient's speech and language deficiency. Thereafter a rehabilitation/relearning plan is a design based on the patient's deficiency level. Technology-enhanced online applications might be a great help for speech therapists to conduct the assessment and relearning sessions for speech therapists (Ahlin et al., 2019). On the other hand, the patients and their significant others might have an improved quality of life and independent living with the use of TES (Freund et al., 2021; Tousignant et al., 2018). However, the use and acceptance of technology are uncertain with the currently available software applications and more research is needed in this context (De Veer et al., 2015; Guo et al., 2021). Since the speech therapists and patients

are potential users, the requirements for the design and development of these applications should be gathered from their point of view and a user-centred design strategy (UCD) must be considered (Tousignant et al., 2018).

1.1 Aim

The study aimed to discuss and define the users' needs for technology-enhanced speech and language relearning following a stroke. Generally, adults are the most common victims of stroke and the related impairments. However, the currently practised speech and language relearning (SLR) applications are not specifically developed for adult people's needs (Ahlin et al., 2019; Egaji et al., 2019). The adult learning theory suggests active participation of adult learners to plan, develop and implement their learning strategy (Knowles et al., 2014). Therefore, adult learning theory was used as theoretical knowledge to identify the users' requirements.

The following research question (RQ1) was addressed as the primary aim of the study:

RQ1: *What would be the user requirements/needs to design an interactive technology-enhanced system for speech and language relearning from medical caregivers' perspective?*

Furthermore, the critical factors influencing the acceptance of technology-enhanced applications were also investigated and discussed in this study. Even though a large number of sophisticated and technically sound software applications are developed in the eHealth field, the acceptance and usability of these applications are uncertain and more research should be conducted to explore the technology acceptance factors (Fischer et al., 2014; Kohnke et al., 2014; Niknejad et al., 2021; Zai et al., 2013). To assess the adoption and use of technology in eHealth, the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2016, 2003) is commonly used in different studies (De Veer et al., 2015; Hanson, 2010; Kohnke et al., 2014). The secondary aim of this study is therefore to explore and evaluate the technology acceptances of SLR application where the UTAUT was used as theoretical knowledge.

The following research question (RQ2) is addressed as the secondary aim of the study:

RQ2:- *What is the technology acceptance of a speech and language assessment application from medical caregivers' viewpoint?*

Considering the proposed factors of the UTAUT model, we hypothesized that technology acceptance and adoption depends upon the belief that the suggested application will be useful (performance expectancy), it will be easy to use (effort expectancy), the viewpoints of user's important others (social influence) and finally the trust on technical infrastructure to support the use of the application (facilitating conditions). A speech and language assessment application for stroke patients was developed and the above-described factors were used as main themes for the evaluation.

1.2 Research Objectives

In order to fulfil the research aim and to answer the research question stated in the previous section, the following four research objectives were formulated and four articles were written to achieve these research objectives.

1.2.1 Objective I:

To explore and highlight the problems within currently available technology-enhanced speech and language relearning

This objective contributes to technology-enhanced SLR by exploring the related research in the field. A position paper (Article 1) and literature review (Article 2) was written to fulfil the objective.

1.2.2 Objective II:

To define the user requirements for technology-enhanced speech and language relearning

This objective contributes to technology-enhanced SLR by understanding the user needs and defining the requirements for technology enhancement. The literature review (Article 2) provides an overall view of related research, and a qualitative study (Article 2) provides an understanding of user needs for technology-enhanced SLR. The users are both the speech therapists and the patients in this context.

1.2.3 Objective III:

To co-create an online speech and language assessment application

This objective contributes to technology-enhanced SLR by co-creating an online speech and language assessment application. The SLR process starts with an initial assessment to diagnose the patient's current speech and language deficiency. The manual assessment system is complex and time taking for speech therapists, which makes it difficult for already physically and mentally patients to concentrate on the assessment exercises. Therefore, the assessment application was developed in a close corporation with speech therapists. The application was based on the gathered requirements in objective II (Article 2), and it was further developed according to the user's feedback in article 4.

1.2.4 Objective IV:

To evaluate the technology acceptance of the speech and language assessment application

This objective contributes to technology-enhanced SLR by investigating the technology acceptance factors for the speech and language assessment application. Since the speech therapists are the major user group for that application, they were involved in the evaluation process. Article 4 was written to achieve this objective.

2 Extended Background

This section provides a background of speech and language impairments and relearning after stroke, the theoretical aspects of the study and the speech and assessment process.

2.1 Speech and language Relearning after Stroke

One of the critical diseases in human beings is stroke rehabilitation which requires lots of resources from hospitals, physicians and patients such as time, money and other costs for its complete prevention (Ahlin et al., 2019). The problems related to speech and language are known as aphasia. Cognitive ability plays a vital role in human health, which is deteriorated by the killer disability factor such as aphasia; which is the main cause of speaking, reading and writing disabilities (Tousignant et al., 2018). It is not necessary that all the patients may get affected with stroke by aphasia, it can be said that a small number i.e., the one-third population gets health issues (Greener et al., 1999; Tousignant et al., 2018). Stroke is one of the problematic diseases during which most of the patients lose their speech abilities and some of them recover soon in a few weeks while others take a longer time to come into a normal routine. It is observed by various conducted research works that recovery mechanisms can be improved with emerging speech and language therapy methods (Gerstenecker and Lazar, 2019).

It is examined by various conducted research works that critical chronic aphasia impacts a lot on the lives of people by destroying their capabilities from social, emotional and communication aspects (Hilari et al., 2003; Øra et al., 2018; Ross and Wertz, 2003). The critical disease aphasia causes anomia in patients, which decreases the speaking ability by creating disorders into the entire health condition (Tousignant et al., 2018).

Without better speaking and communication traits it is difficult for the patients to express their health conditions, feelings and thoughts to others, which is a major challenge to minimize the mental disorder and burden (Øra et al., 2018). The rehabilitation process is necessary and a key role player to recover from speech and communication loss due to aphasia; this not only helps the patients to get better health conditions but also coming back to their normal life routines (Øra et al., 2018).

SLR is the fundamental process to help the patients to regain their different lost features, for instance, reading, writing and emotional expressions (Brady et al., 2016). In addition, it is observed and analysed by various previous researchers that long term well-planned therapy and interventions are more effective unlike short-term therapy plans (Øra et al., 2018).

2.2 Knowles' Adult Learning Theory

Adult's education and learning methods, for example, effective learning models and andragogy principles are the paradigm shifts to promote the awareness, self-learning and development phases practically (Chesbro & Davis, 2002; Kaufman et al., 2009). It is revealed from extensive existing surveys that andragogy i.e., adults learning patterns are usually different from the conventional children's learning and practising methods i.e., pedagogy (Knowles et al., 2014). Mostly detailed planning and deployment mechanisms are followed in the adult's learning process to achieve the accurate and long-term goals (Knowles et al., 2005), which addresses the following six key features of adult learners.

2.2.1 Need to know

It is mandatory for adults to understand the importance of learning and desired outcomes before starting the proper learning steps with clear limitations, and advantages. Because they need more energy, ambitiousness and encouragement with clear goals of learning, otherwise it is relatively hard to convince them and get them out of their comfort zones.

2.2.2 Self-concept

From the learning and self-responsibility aspect, adult learners are more mature, dedicated and decisive to understand things in a better way. In addition, they are more inclined to collaborative and cooperative ways of learning than the children.

2.2.3 Learning from experiences

The experience and conclusion drawing with accurate analysis and perception are the impressive traits of adult learners. Due to these characteristics, mentors and instructors are feeling comfortable and convenient to deal with their queries effectively and distinctly with good belief and trust in their learning capabilities.

2.2.4 Readiness to learn

Previous research works have addressed the key role of adult's past experiences and imperative traits of integrating personal and professional experience for clearly understanding the particular fields. The active and long social behaviour makes them more capable to learn and cope-up with the latest trends.

2.2.5 Orientation to learning

Adults tend to learn the skills that help them to change their overall life circumstances. The mature and effective learning capabilities direct the adults to understand the social and real-life situations with a key focus on the problem-driven strategies instead of the subject-enabled.

2.2.6 Internal motivation

The high motivational and encouraging entities, for instance, good job, better salary, and less stressful work-environment impact the learning capabilities in the education sector and industrial environment. While adult learning is more concerned with the high and standard quality of living, high respect and values in their personal lives, because this will not only make them self-confident but also self-sufficient and good mentors.

2.3 The Andragogy in Practice Model

The Andragogy in practice Model is a conceptual framework that is built on the above-described adult learning principles. It is observed and revealed through the extensive survey that stroke is a critical disease mostly happening to adults, and practically it is vital to adopt the Andragogy models for speech and language re-learning mechanism as shown in Figure 1. The model directs towards three adult learning dimensions (Knowles et al., 2014). The main goals and objectives of the adult learners are considered as the developmental outcomes as shown by the outer ring in Figure 1. While organizational improvement classifies the goals into three types, for instance, individual, social and institutional growth of the learner. The middle ring highlights the individual and situational differences with better insight on the learning with detailed classification into learning differences i.e., individual learner differences, subject matter differences, and situational differences. The fundamental six elements of adult learning are considered as key enablers to boost learning through technological trends to regain speech and language learning abilities. Finally, the outer and middle rings in the andragogy model are used as filters to clearly differentiate the requirements for technology-based stroke patients as follows.

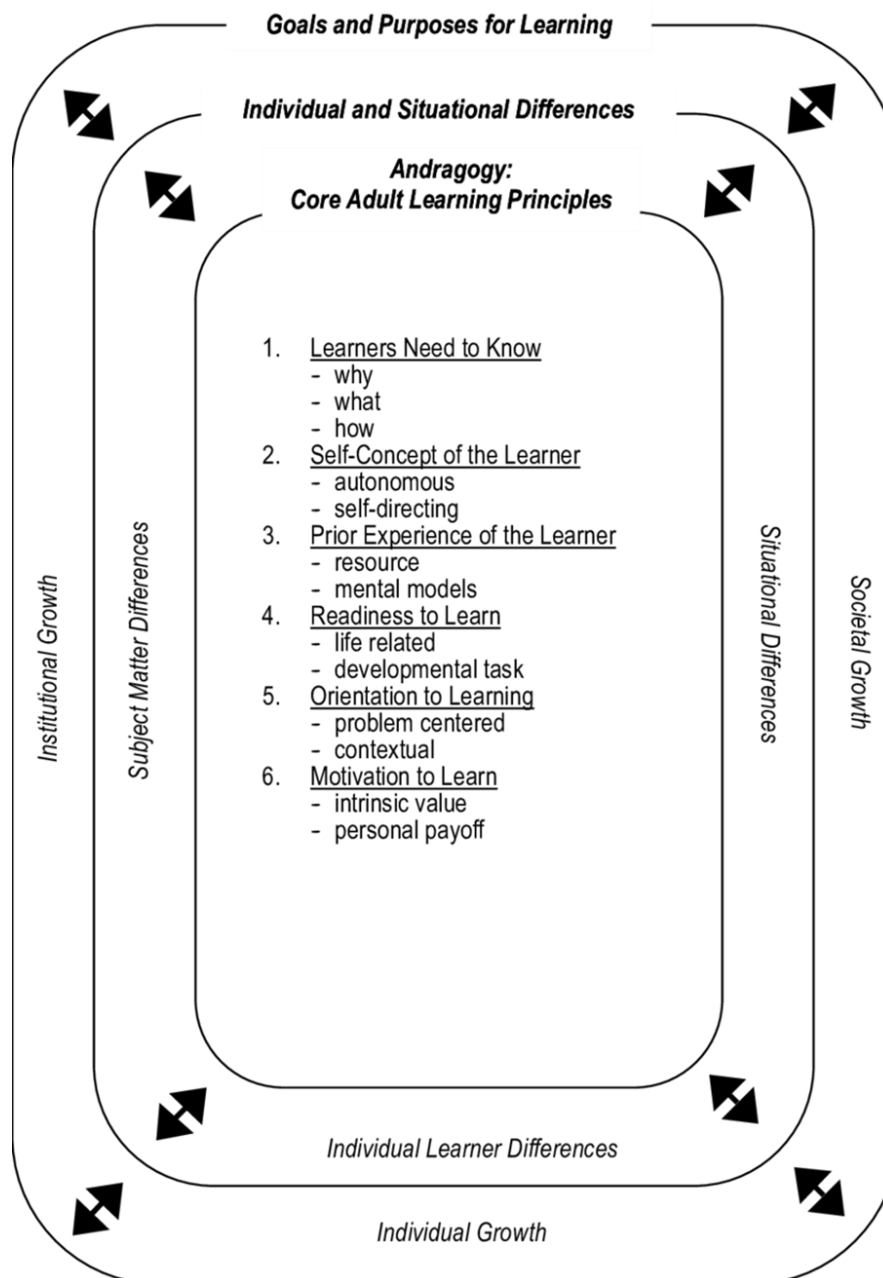


Figure 1. Andragogy in Practice Model. Source: Knowles et al. (2014).

2.4 Unified Theory of Acceptance and Use of Technology (UTAUT)

A well-known model named 'Unified Theory of Acceptance and Use of Technology (UTAUT)' adopts the technology for analysing and assessing the behaviour and intentions of the users (Venkatesh et al., 2003). The UTAUT model is classified with the help of eight distinct models and theories, which were previously incorporated with the Technology Acceptance Model (TAM), while TAM is well-equipped with the technological trends for assessing the intentions and notions (De Veer et al., 2015; Kohnke et al., 2014; Wiklund Axelsson and Melander Wikman, 2016).

The extensive study of the eight emerging models by Venkatesh et al. (2003) portrays that technology is the key role player with close association to the four basic factors: Performance expectancy, effort expectancy, social influence and facilitating conditions. The TAM model defines the performance expectancy as "perceived usefulness", and effort expectancy is stated as "ease of use". It can be said that the UTAUT model is the enhancement of the TAM model with two additional entities such as,

Social influence and facilitating conditions (Garcia, 2019; Mallet et al., 2019; Marshall et al., 2019; Tousignant et al., 2018). Thus, the UTAUT model is the theoretical framework with four major technology integrated elements.

2.4.1 Performance expectancy

It is revealed by Venkatesh et al. (2003) that the intention to use technology is directly related to the user's belief about the given system will enhance their performance. Also, the addition of technology in today's era makes the lives of everyone convenient and remarkable (Venkatesh et al., 2016).

2.4.2 Effort expectancy

Effort expectancy is referred to the user's belief about the easiness of system use. Venkatesh et al. (2003) highlighted the easy and convenient system for the society in collaboration with the experts and technology giants is necessary, because it shall provide better learning platforms with improvement in the skills and progress in the outcome. The effective and less complex learning platform gives quick insight and viable opportunities in a sufficient span of time (Venkatesh et al., 2016).

2.4.3 Social influence

Venkatesh et al. (2003) suggest that the viewpoints of other important and relevant people influence the individual's intention to use that system. These viewpoints can give better collective insight and guidelines for an effective system. For proper system utilization, it is vital to allocate fair resources, which is impacted by the beliefs and intentions at any institution. The entire system's orientation and management platform is the reflection of an effective role of senior workers, managers and supervisors in association with the emerging technological trends.

2.4.4 Facilitating conditions.

The facilitating conditions are defined as "The degree to which an individual believes that an organizational and technical infrastructure exists to support the use of the system" (Venkatesh et al., 2003). It is of great importance that the new system should be according to the user's previous and existing work routines (Venkatesh et al., 2016).

2.5 Speech and Language Assessment System (A-ning) Overview

A-ning is derived from the Swedish word 'Aning' and its translation in English is 'Clue'; that is symbolised as getting a clue of a stroke survivor's speech and language impairments. These impairments are generally known as Aphasia. After the stroke, a detailed assessment of the patient's current condition of speech and language impairments is conducted before planning the relearning process. The assessment is conducted as a standardized procedure called "A-ning" that involves a set of detailed exercises (Lindström and Werner, 2000).

A-ning test consists of paper and pen martial, and it is developed in Sweden. A-ning is considered the most comprehensive test and it is commonly used in rehabilitation centres throughout the country (Ahmad et al., 2020). Before starting the standardized procedure, the speech therapists decide which exercises to be conducted, and it is based on the patient's described injuries. Speech therapists (main participants in the study) suggested that the analogue assessment system should be converted into an online application so that the results will easily be stored in the system and used as initial input for the patient's relearning.

2.5.1 The assessment and implementation process

The assessment material consists of a task folder called “A-Ning” that contains different types of tasks and exercises. A-Ning contains 21 pages with images and text-based material for the patients called “P-pages” and 20 pages of data and instructions for the speech therapist called “L-pages”. The folder also contains 63 text cards with words and sentences for reading comprehension and alternative writing tasks. A-Ning comprises 44 tasks where each task may have 1-10 sub-tasks. For the eight writing tasks, there are also the possibilities of alternative execution of tasks for patients with severe motoric impairments (Lindström and Werner, 2000, 1995).

An example of the patient’s page is shown below in figure 2. The patient looks at the picture and answers different questions asked by the speech therapist.

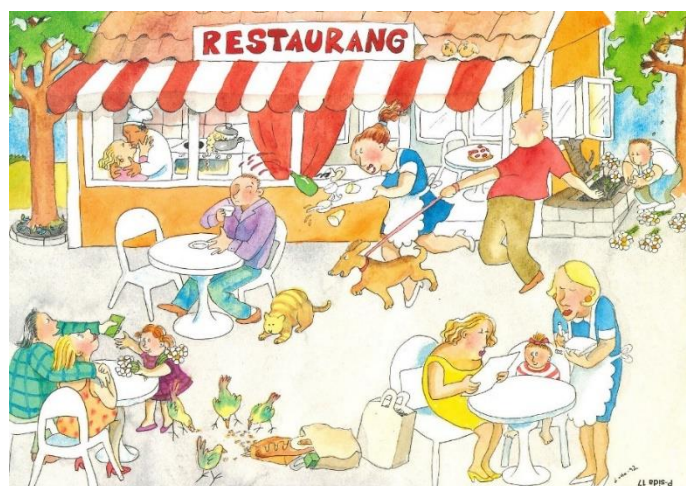


Figure 2. Patient’s page

The corresponding page for the speech therapist is shown below in figure 3. The page contains metadata of the task, instructions to perform the task and points achieved in the task. The total achieved points in all performed tasks in the assessment process decide the impairment level of the patient.

L-sida 14		
UPPGIFT	INSTRUKTION/DELUPPGIFTER	POÄNGSÅTTNING
A7. INFORMATIVT TAL Beskrivande tal – Tematisk bild	<p>Visa P-sida 17!</p> <p>Patienten ska göras uppmärksam på detaljerna om de inte beskrivs spontant. Cirka tio händelser kan beskrivas med meningar i valfri ordning. En sammanhängande berättelse förväntas ej.</p> <p>Beskriv den här bilden. Tänk dig att jag inte ser den. Berätta vad som händer?</p>	<p>Poäng: Enligt manual</p>
A8. INFORMATIVT TAL Berättande tal – Förlopp	<p>Visa ej P-sida!</p> <p>Händelseförloppet ska beskrivas med minst fem moment i logisk följd.</p> <p>Beskriv ett restaurangbesök. Hur går det till? Vad gör man först? Vad händer sen? Tänk att du/ni berättar för någon som aldrig varit på restaurang.</p> <p>Alternativuppgift kan ges om patienten är helt obekant med händelseförloppet vid ett restaurangbesök. Patienten kan då i stället berätta om ett annat händelseförlopp med minst fem kronologiska moment, t ex baka en sockerkaka eller byta däck på bilen.</p>	<p>Poäng: Enligt manual</p>

Figure 3. Speech therapist’s page

The assessment process can be completed in one hour but usually take a longer time. It is, therefore, recommended to divide the assessment into several sessions according to the patient's condition. There should not be a long time gap between the sessions and the assessment should be completed within a week.

The speech therapist starts with the L-page and gives the corresponding P-page to the patient. The speech therapist asks the patients to perform different tasks according to the instruction written on the L-page, the performed tasks are then assessed and points are given according to a grade scale. The task is arranged in a logical order and it is recommended to follow the given sequence. However, the therapist may switch between different tasks and may change the order of tasks according to the situation. In principle, all tasks should be performed during the assessment, however, if it is quite obvious from the previously provided information that the patient will not be able to perform/pass a task, it should be excluded and the achieved points will be set to zero in the point table.

3 Methodology

This chapter proposes detailed methodological choices and their justification. Overall research design, important activities in the design process and how those activities are related to the included research articles are discussed in later sections. Thereafter, step by step research strategy, its proper usage, and theories are described in a detail, and in the last, ethical considerations and their importance is revealed.

3.1 Research Design

Research methodology can be described as a systematic process of solving a research problem by making some methodological choices with logical justifications (Vanderstoep and Johnson, 2008). In the information systems (IS) field one common research approach is to create and evaluate the artefacts to solve an identified research problem (Johannesson et al., 2013; Johannesson and Perjons, 2012; Oates, 2005). An artefact in IS research can be a method or a model, or a fully functional system that may help researchers to evaluate some specific approaches and/or models. This idea of designing and evaluating the artefacts is available in literature as design and creation research (Oates, 2005), action research (Avison et al., 1999) and design science research (Hevner et al., 2004; Johannesson and Perjons, 2014). Several studies on eHealth have used these approaches for the development and evaluation of TES (Davoody, 2016; Kraus et al., 2021; Lin et al., 2021; Prodanoff et al., 2021).

The design science research (DSR) approach was adopted to create, implement and evaluate the speech and language assessment application for answering the research questions in an accurate and proper way (Johannesson and Perjons, 2014). The five activities of DSR are performed with a logical sequence; the output of one activity becomes an input of the next activity as described in Figure 1.

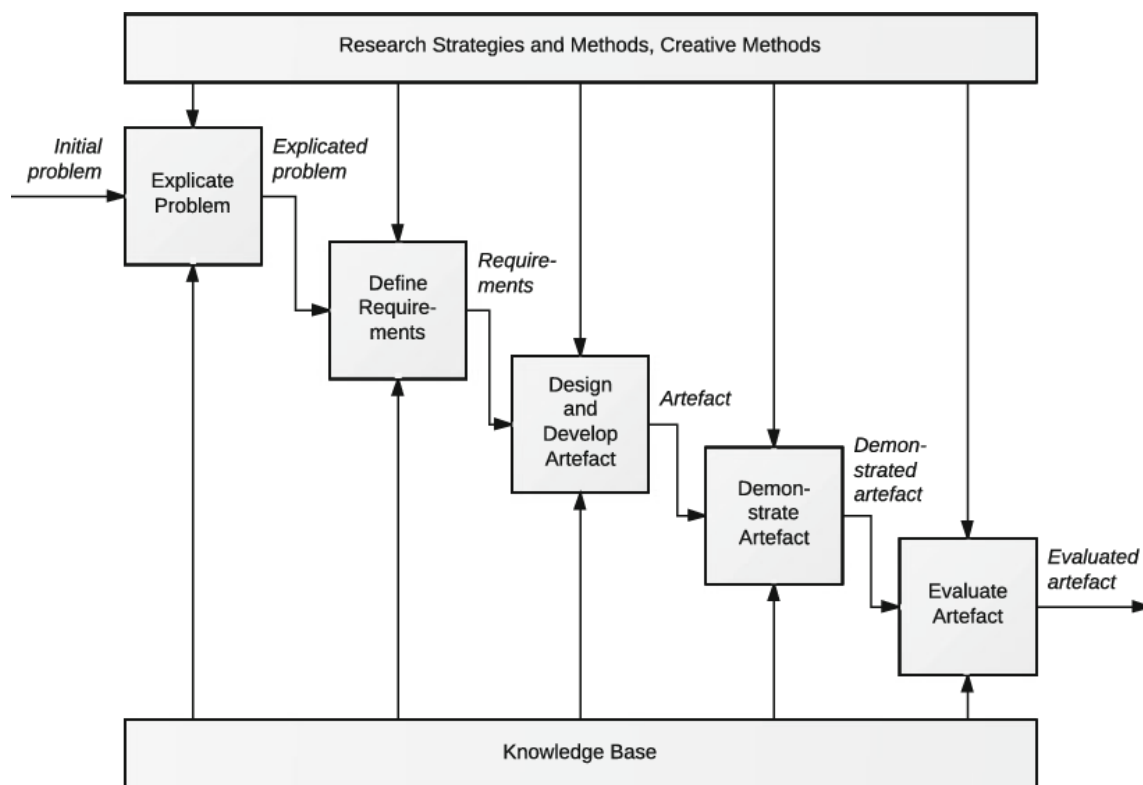


Figure 4. Step-wise Design science process (Johannesson and Perjons, 2014)

As suggested by Johannesson and Perjons (2014), each activity in the process is divided into different sub-activities and four channels are related to each activity; these four channels are input, output, controls, and resources. Figure 4 provides a generic template to conduct the activities in the DSR process; that template is adopted and used according to the guidelines of Johannesson and Perjons (2014). Input describes the knowledge and/or object that is available before the activity, and output describes the knowledge and/or object gained after the activity. The controls give us a mechanism for governing that activity such as, the research strategies and methods that are used to perform the activity. Resources on the other hand give us the base knowledge (i.e., theories and models) to perform the activity. The following section gives a detailed overview of how different theories and methods are incorporated in different activities of this research.

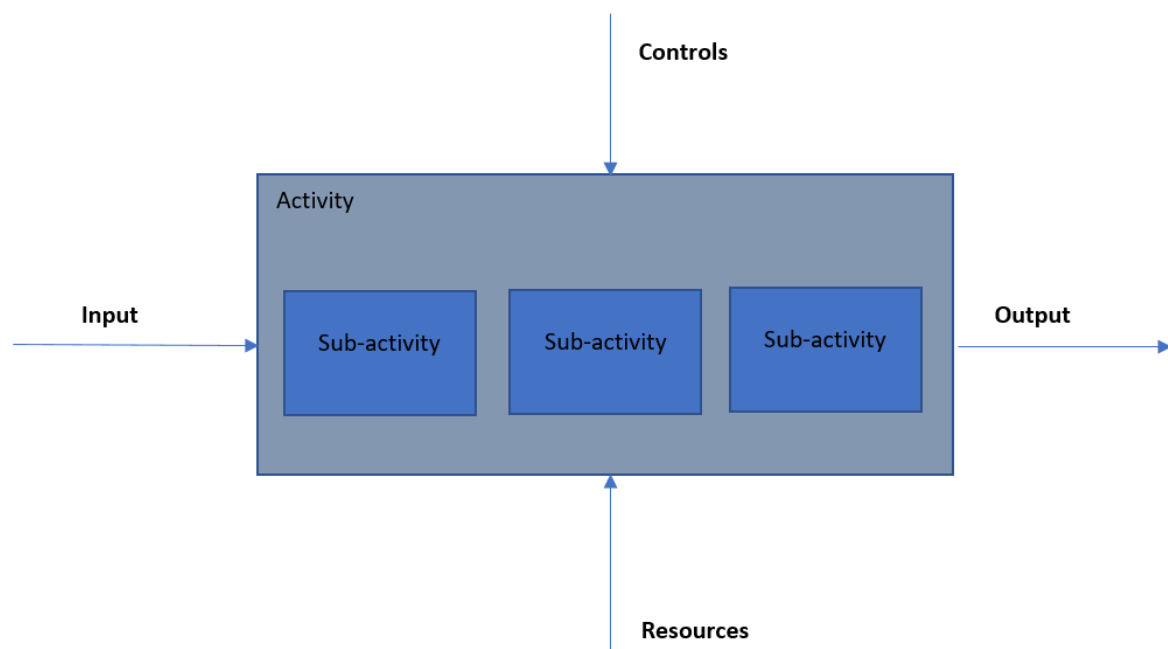


Figure 5: A generic template to perform different activities in DRS (Johannesson and Perjons, 2014)

3.2 Design Science Activities

As described in the introduction section, this study was divided into four research objectives. In order to achieve these research objectives, four research papers were written and different DSR activities were performed. The following table 1 gives an overview of how those articles are interrelated to the research objectives and DSR activities.

Table 1. The relation between DSR activities, research objectives and the included articles

Design Science Activities	Research Objectives	Articles
Explicate Problem	1	1
Define Requirements	2	2 & 3
Design and develop artefacts	3	2 & 4
Demonstrate artefact	4	4
Evaluate artefacts	4	3 & 4

In the following subsections, all the performed activities are discussed in a detail.

3.2.1 Explicate problem

The first activity was to explicate the problem by understanding and analyzing it properly. Figure 5 presents the process of problem explication as recommended by Johannesson and Perjons (2014). During the interviews with speech therapists, an initial problem was defined as, the use of technology-enhanced systems (TES) for speech and language relearning (SLR) is doubtful.

A position paper (Article 1) was written to define the aforementioned problem precisely. This position paper is based on literature studies and the author's previous knowledge about technology-enhanced stroke rehabilitation. The problem was poisoned and justified and finally, the root causes of the problem were identified. As shown in figure 5, semi-structured interviews and literature study were used as methods, and the user-centred design (UCD) approach was used as theoretical base knowledge. The explicated problem was further addressed as, the currently used TES are not specifically designed according to the stroke patients' and speech therapists' needs, and the user participation and empowerment is compromised in the system development process.

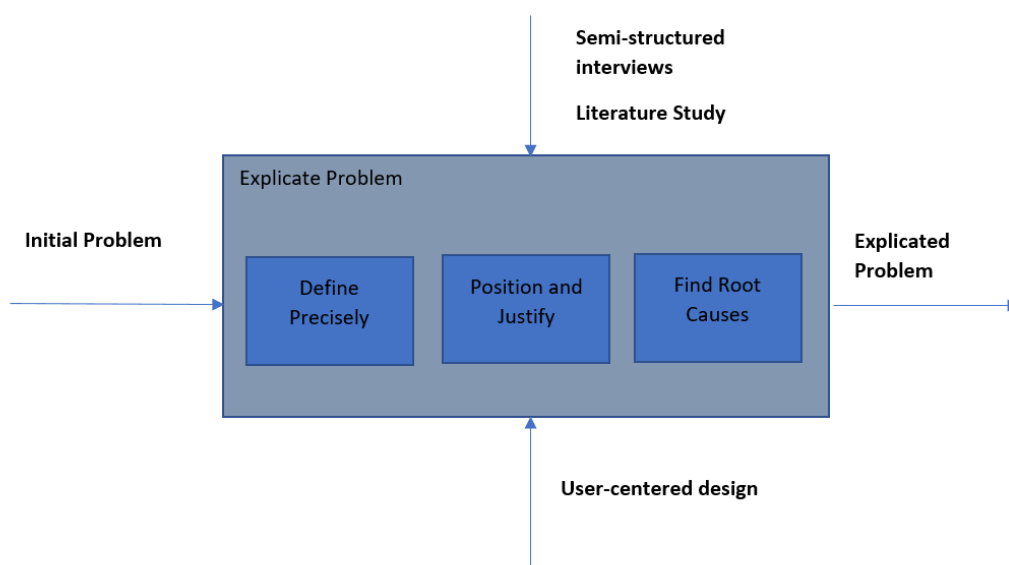


Figure 6. Explicate problem

3.2.2 Define requirements

As demonstrated in figure 6, the second step outlines an artefact and defines its requirements. According to DSR strategy, this question *“What artefact can be a solution for the explicated problem and which requirements on this artefact are important for the stakeholders?”* must be addressed properly (Johannesson and Perjons, 2014).

The outlined artefact was “an interactive speech and language assessment application for stroke patients”. The most relevant and key stakeholders were involved to understand the requirements for the application development. Article 2 was written to define the requirements for the application development; where adult learning theory thematically represents base knowledge.

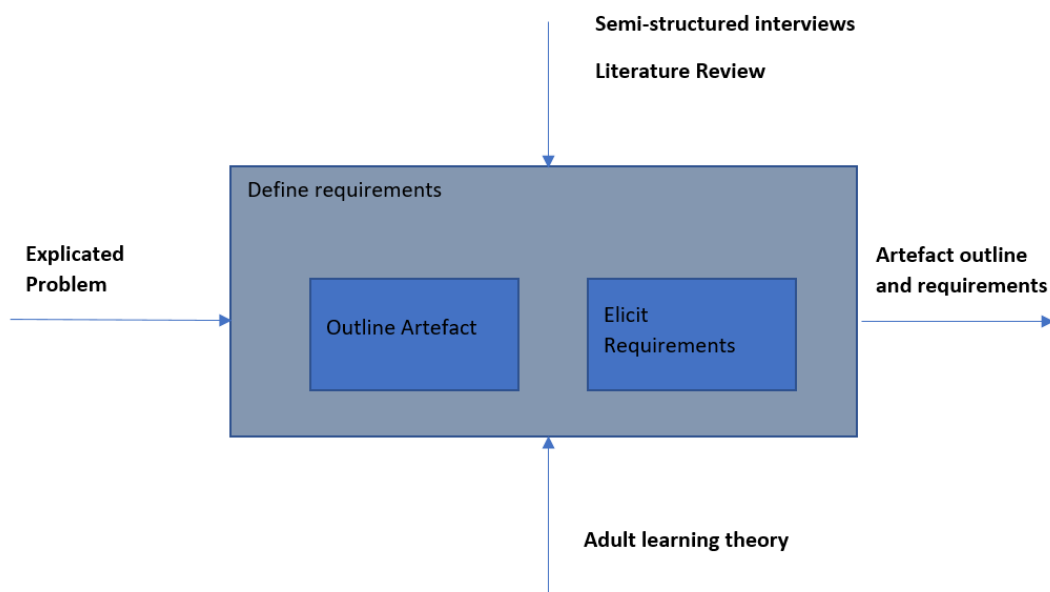


Figure 7. Define requirements

3.2.2.1 Data collection and analysis

Semi-structured interviews were conducted for data collection. The selection of motivated and enthusiastic participants with expertise and deep knowledge in their fields plays an important role in understanding and highlighting the requirements (Wieringa, 2014). To select highly expert and knowledgeable participants, a purposeful and decisive sampling strategy was adopted. All the participants with healthcare backgrounds were good with expertise in stroke rehabilitation, especially in SLR. Participants 9 and 10 have an IT background with good knowledge about TES and a strong association with SLR.

The 11 selected participants, their professional roles and experiences are presented below in table 2. Since one of the objectives of this study was to determine the overall requirements for technology-enhanced speech and language relearning, broader and comprehensive requirements were gathered for that purpose. These requirements were described and discussed thoroughly in article 2. However, the outlined artefact was the speech and language assessment application, therefore, the requirements needed for that assessment application were taken further for the design and development of the artefact. Both functional and non-functional requirements for the application are presented in Appendix 1.

Table 2. Selected participants for interview

Participants	Professional role	Years of experience
Participant 1	Speech therapist #1	25
Participant 2	Speech therapist #2	4
Participant 3	Speech therapist #3	5
Participant 4	Stroke specialist doctor and manger in the regional hospital	25
Participant 5	Occupational Therapist	5
Participant 6	Physiotherapist #1	8
Participant 7	Physiotherapist #2	3
Participant 8	Chairman of the local stroke patients association	3
Participant 9	CEO of en IT company working with game-based stroke rehabilitation	25
Participant 10	IT specialist at a multinational IT company	9
Participant 11	Manager of Mobile Stroke Team	15

A deductive thematic analysis approach (Braun and Clarke, 2012) was adopted for data analysis. In the first step, interviews based on transcripts and audio recordings were carefully explored for coding. The important features of data that are directly relevant to the speech and language re-learning were established. The identified codes were examined and categorised using the adult learning principles (Knowles et al., 2014) as basic themes.

The next step was to select and finalize important themes. The initial themes were thoroughly reviewed and the relevant themes that were important to answer the research question were selected. The most relevant and essential themes were categorised and presented according to Knowles adult learning principles.

3.2.3 Design and develop artefacts

Designing the new artefacts might improve the real world and its related problems (Hevner et al., 2004; Johannesson and Perjons, 2014). Therefore, after establishing the requirements of an outlined

artefact, the next logical step was to design and develop an artefact. The developed artefact should address the explicated problem as well as it should meet the desired/standard requirements (Johannesson and Perjons, 2014).

DSR gives a well-structured design and development platform for the artefact as demonstrated in figure 7. The four sub-activities, Imagine and Brainstorm, Sketch and Build, Assess and Select, and Justify and Reflect were performed in three iterations. Two sessions with the speech therapists were conducted for brainstorming and free discussions. The user-centred design (UCD) and software engineering was used as base knowledge for the design and development of the application.

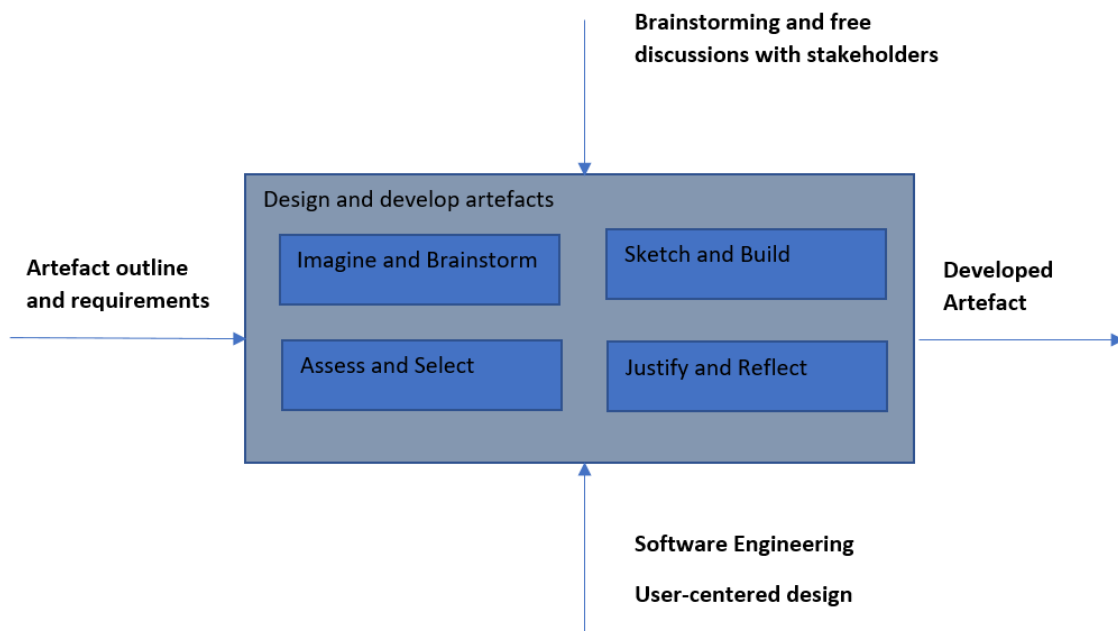


Figure 8. Design and develop artefacts

The identified requirements are used as logical input, however, the users were involved throughout the process of design and development. To ensure user empowerment, the UCD approach was adopted as theoretical knowledge (Anderson, 1988; Still and Crane, 2017). Speech therapists 1 and 2 who are potential users of the application were involved in the application design and different functionalities of the application.

As described above, two sessions were conducted with the speech therapists for brainstorming and discussions about application design. In the first session, a simple on paper sketch/design and tentative workflow of the application was discussed with the speech therapist 1 and 2 (see APPENDIX I). The application design and workflow was adjusted to the user's needs after that first session.

An evolutionary prototype was developed after that first session. The evolutionary prototype gives the software developer a starting point of the application development, yet it provides the opportunity to alter the interface at the initial stage (Kunicina et al., 2020). The entire system can be developed on top of that prototype. In the second session, the prototype was presented to the speech therapist 2. An initial assessment of the application interface and different functionalities was made

in that session. Most of the functions were finalised, however, more tailor-made functions were suggested by the speech therapist. The suggested functions were added to the application in the second iteration.

The application for speech and language impairments assessment was developed with the help of Microsoft SharePoint as a platform and PowerApps as a tool (Power, 2020). PowerApps provides an easy-to-use and secure collaborative tool with simple and convenient changes in the interface at different stages of development (Pearson et al., 2020). After performing two iterations, the application was ready for the demonstration in the next step of DSR.

3.2.4 Demonstrate artefact

The purpose of this activity was to make an initial evaluation of technology acceptance for the developed speech and language relearning application. The application was tested in only one session with one speech therapist. As suggested by Johannesson and Perjons (2014), the artefact should be initially tested in one case, and if the artefact gives the expected outcomes in one case, it might give the same results in several cases. This initial evaluation helps researchers to make initial assumptions about the effectiveness of the artefact. If the artefact solves the identified research problem in one test case, we should move forward to the next activity where a detailed evaluation will be conducted, otherwise, we should go back to the previous activity and redesign the artefact (Johannesson and Perjons, 2014).

Figure 8 presents an overview of the artefact demonstration activity. A test scenario was designed to assess the effectiveness of the application. The test scenario contains different tasks followed by some interview questions (see Appendix 1). Unified Theory of Acceptance and Use of Technology (UTAUT) was used as base knowledge for making an initial evaluation of technology acceptance (Venkatesh et al., 2016, 2003).

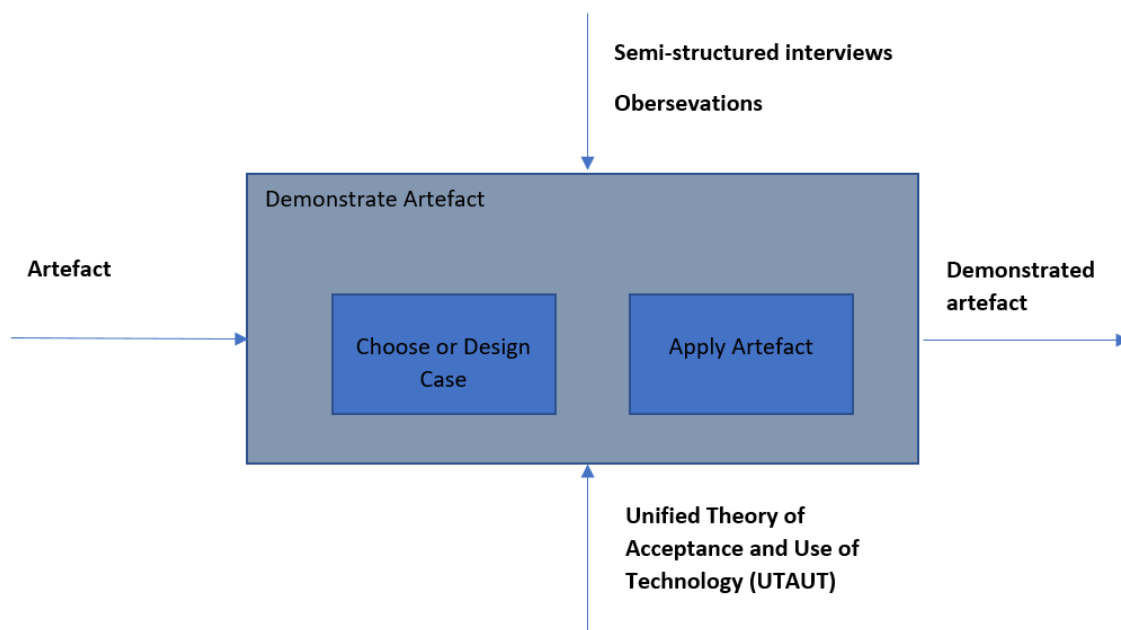


Figure 9. Demonstrate artefacts

Speech therapist 1 participated in this activity and the demonstration was performed in two sessions/iterations at the regional municipality rehabilitation centre. The first session was 90 minutes long and three researchers participated in this session. Researcher 1 gave a detailed briefing on the application and the tentative tasks and later assisted the speech therapist to perform those tasks. Researchers 2 and 3 asked questions, made the observations and wrote down the initial notes.

Thereafter, in a separate meeting, all the researchers discussed and analysed the gathered data and concluded that the application is effective for aphasia assessment, however, it needed some alterations to synchronize it with the speech therapist previous work routines. After making those alterations, the application was ready to make a detailed evaluation with several speech therapists. The screenshots of the final application are presented in APPENDIX II.

3.2.5 Evaluate artefacts

This subsection thoroughly evaluates the demonstrated artefact. The purpose of this activity is to assess how well the artefact meets the desired requirements and solve the defined problem (Johannesson and Perjons, 2014) as presented in Article 4. The process of evaluation is structured and visualized in figure 9. This activity was divided into three subsections; the first was to analyse the context followed by determining the goals and strategy for the evaluation and finally the evaluation was carried out. Since the old speech and language impairments evaluation consists of a manual paper and pen (see APPENDIX II) and the new technology-enhanced system is developed to meet the user needs technologically; one important context was identified as the evaluation of technology acceptance. UTAUT was used as a theoretical foundation for data collection and analysis in the evaluation phase (Venkatesh et al., 2016). The interview questions were also structured according to the four determinant technology acceptance of factors of UTAUT theory.

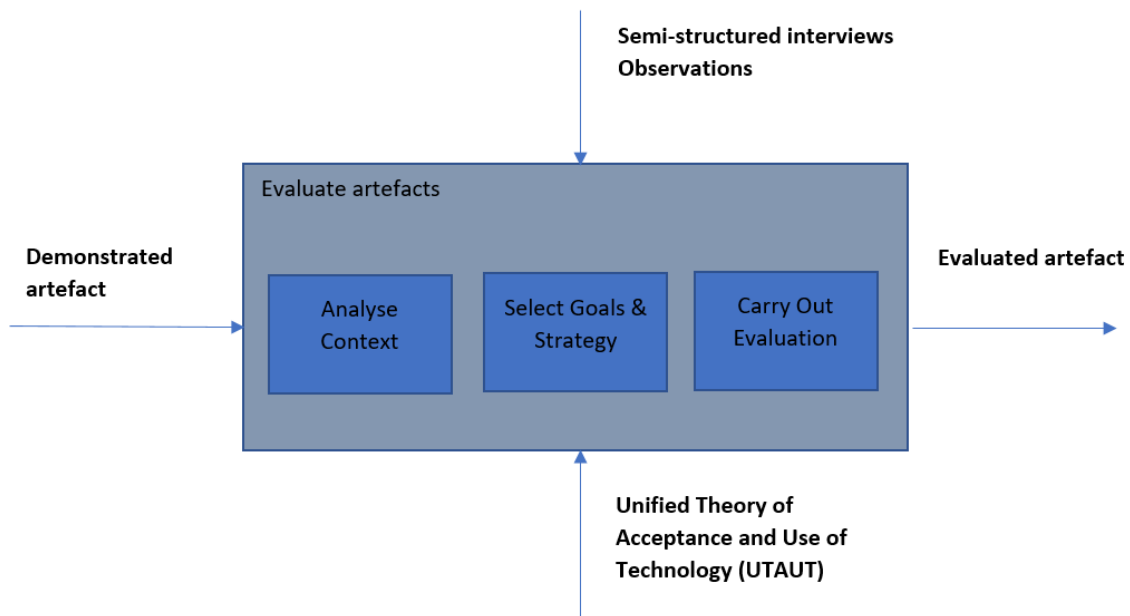


Figure 10. Evaluate artefacts

Three speech therapists participated in the evaluation activity (Participant 1-3, Table 2). In total, four sessions were conducted with the speech therapists and each session was approximately two hours long. The same test scenarios and interview questions were used for both demonstrate artefact and evaluate artefact activities (See APPENDIX III). Due to the pandemic conditions after covid-19, some

of the study participants were working from home. Therefore, the first three sessions were conducted at the regional rehabilitation centre where only one researcher was physically present and the two researchers participated online. The fourth session was completely conducted online. Zoom Meetings Platform was used for online sessions, and recordings (Archibald et al., 2019).

Each session started with a short introduction of participants and a declaration of the ethical aspects of the study. The details of the ethical aspect are present in the discussion section. Thereafter, the agenda and proceedings of the meeting were presented. A detailed briefing on the speech and language assessment application was then given. The different functionalities of the application and how these functions differ or similar to the old paper and pen system were described in that briefing. Next, the participants were asked to perform tasks and the technology acceptance of the application was observed. After the technology acceptance tests, the complementary interview questions were asked to the participants. Finally, the session was concluded and acknowledgements were presented to the participants.

As used in the requirements identification phase, a deductive thematic analysis (Braun and Clarke, 2012) was conducted to analyse the empirical data. The same previously described (in the Define Requirements phase) procedure was repeated in the evaluations phase. The interview recordings and written notes were explored and analysed multiple times for coding. The important codes that were relevant to explore the acceptance of technology-enhanced speech and language relearning were identified. The identified codes were then categorised according to the UTAUT model's technology acceptance factors as basic themes. Finally, the themes were carefully reviewed and analysed to answer the research question.

3.3 Ethical Considerations

Ethics are very important to consider, particularly when designing and developing solutions and IT systems for medically impaired people (Hewson and Buchanan, 2013a). In this study, the guidelines and rules from the Swedish Research Council (CODEX) were adopted for ethical considerations (Eriksson, 2015). CODEX suggests that the conducted research should be beneficial and productive to the society, the national and local rules to conduct the research should be followed, and professional codes of ethics should be considered (Eriksson, 2015).

All the participants in the studies were informed briefly about the purpose and procedures of conducting this research and the considered ethical aspects. Each interview started with the information that the participants can withdraw from the interview at any time and they are free to answer or unanswered any questions during the interview. Moreover, they were informed that the gathered information will only be used for academic research purposes.

Another important ethical aspect is to consider the anonymity and privacy of the study participants (Kvale et al., 2014). The participants were informed that their identities will not be disclosed in the research articles and reports. All the interviews were audio-recorded and stored securely at the university database that can only be accessed by the research participants. A detailed discussion about the ethical aspects is presented in the Discussion section.

4 Findings

This section describes the summary and findings of the four included studies, their relation to the four research objectives, and the fulfilment of those objectives.

4.1 On the Importance of Tailor-made Speech Relearning Software for Stroke Rehabilitation

4.1.1 Summary

This position paper was aligned with research objective 1, *“To explore and highlight the problems within currently available technology-enhanced speech and language relearning”*. It provided an overall understanding and motivation of the overall study. Based on the literature study and interviews with the speech therapists, the author argues for the importance of tailor-made software applications that are specifically designed after the users' needs.

4.1.2 Main Findings

The study highlighted major issues with the currently available software applications and suggested their tentative solutions. Speech and language relearning is a long term and intensive process that requires a lot of financial and human resources in hospitals and rehabilitation centres. The use of technology in relearning process might decrease the burden on medical caregivers and it also provides faster and easier recovery to the patients. Several software applications are currently available, however, the potential users (patients and speech therapists) are doubtful about the usability and effectiveness of these applications.

One major identified issue was that the currently used applications are not specifically designed for stroke patients. The speech therapist at the regional hospital mentioned that they are using an online application for speech learning exercises that was developed for school-going children. This speech learning application consists of exercises and games that are interesting for children but the adults find those activities boring. Since the majority of stroke patients are adults, it is very important to build these according to the target groups' age.

To empower the users (speech therapists and stroke patients) and enhance their participation, a user-centred design approach must be applied and both speech therapists and stroke patients must be involved in the entire design and development process. The role of the User Experience (UX) designer is vital in this context. The UX designer works with both the users and the software development team, which provides better user participation and empowerment. Therefore, a qualified UX designer or UX researcher should be engaged in prototyping and software development.

4.2 Speech and language relearning for stroke patients- Understanding the users' needs for technology enhancement

4.2.1 Summary

The main purpose of this study was to understand and identify the requirements for technology-enhanced speech and language relearning. As highlighted in the previous section (Article 1), the currently available SLR applications do not specially design for stroke patients. Some of the applications are built for children learning but they are used by speech therapists and adult patients in the local municipality hospitals. Both the speech therapists and the patients were not satisfied with

those applications. The requirement focused design science approach was used in this study (see Method chapter, Define requirements).

The following research questions were addressed in this study:

1. *What are the requirements for designing an interactive software application for speech relearning exercises following a stroke from medical caregivers perspective?*
2. How the principles of adult learning might support speech and language relearning for stroke patients?

Mostly, adults suffer from stroke; therefore, the adult learning principles were used for understanding the users' requirements. Initially, the study highlighted the overall requirements for technology-enhanced speech and relearning. During this requirement gathering phase, the speech therapists emphasised that the speech and language assessment application should be designed first. The requirements for that application are described in Appendix 1, and the general requirements are presented in the following subsection.

4.2.2 Main Findings

The overall requirements for SLR were categorised and presented according to Knowles adult learning principles.

4.2.2.1 *The patient's need to know*

The patients want to know the usefulness of their relearning objectives in their daily life. Most of the participants highlighted the importance of involving the patients to establish their relearning objects (Participants 1 – 4, 11). The patients would like to know about the potential benefits of doing the suggested exercises and the drawbacks of not doing those exercises (Participants 2 - 3).

4.2.2.2 *Self-concept of patients*

The adult patients are generally self-directed and they are keen to know about their loss after stroke and its relearning process (Participants 5 – 7). The patients like to get this information from their loved ones, i.e. their friends and close relatives (Participants 2, 5-7). The patient's relatives and friends should be educated about the intended software application so that they can help the patients in the home environment (Participants 2, 3). Additionally, the software should allow the patient's close relatives to log in and participate in the therapy sessions with speech therapists; this will help patients in performing the exercises and the speech therapists will also get help in guiding patients to perform those exercises (Participants 2).

4.2.2.3 *Adults patients learn from their experiences*

The previous knowledge and experiences about the use of technology make a perception about the given technology; therefore, it is important to consider the patient's previous experience of technology-enhanced systems (Participant 2, 3). Considering their previous use of technology, the users should be given education and training about the efficient use of technology.

Education and training are not only important for the patients but the speech therapists equally need them (Participant 2). The health caregivers face many technical problems in arranging the staff meeting with their colleagues; therefore, it will be even more challenging for them to set up online meetings with the patients that have physical and cognitive impairments (Participant 2, 3). Especially the older adults face more technical issues than the younger generation, and the post-stroke disabilities make it even harder for them to use technology (Participants 1, 4-7).

Most of the language relearning software applications are developed in the English language; however, the study participants emphasised the use of native (Swedish) language (Participants 2, 11). With an increased number of immigrant stroke patients, the hospitals have to spend many resources for translation services; an option of selecting from different commonly used languages will be useful in this context (Participant 11).

4.2.2.4 Readiness to learn

The users should be ready and well prepared for the technology use. Most of the study participants highlighted that the technology acceptance aspects such as ease of use, usefulness and trust in the system should be considered carefully (Participants 1-8, 11). The ability to adopt and use the TES also depends upon the patient's overall health after stroke (Participants 5-7).

The patients should see the use of TES as a joyful activity rather than an unwilling task that they must have to perform. Therefore, the TES should be entertaining and it should give the patients a feeling of satisfaction and pleasure (Participant 4). Involving games, music and dance can definitely enhance the patients' relearning after stroke (Participants 4, 8).

4.2.2.5 Orientation to learning

The treatment strategy should be focused on the person rather than his/her disabilities. The medical caregivers emphasised that the user's requirements are different based on the user's medical, social and professional background (Participant 1-7). Therefore, a personalised relearning plan is needed for the patients with special considerations about their medical, social, and professional backgrounds. For example, people with damaged cognition usually feel difficult to comprehend the complex text in the interfaces (Participant 1). Therefore, the record and replay function for pronunciation training and image-based navigation functions for language training are helpful for communication (Participant 1, 2). The stroke patient's vision can be blurred; therefore, the interface should have larger text and images (Participant 1, 2). Eye-tracking functions might be useful for patients with severe motoric disabilities (Participants 10). Furthermore, the software should be platform independent so that the hardware can be chosen according to the patient's personalised relearning plan.

4.2.2.6 Internal Motivation of patients to relearn

The patient's internal motivation to use the TES is also important, and they should be briefed in detail about the potential benefits of using a specific technology (Participants 1 - 4). For example, relearning communication skills for a politician is more important than physical rehabilitation for a football player and vice versa (Participant 2). Living independently is also an important internal motivation for stroke survivors. After initial treatment at the hospital, the patients like to go home as soon as possible and generally; the relearning process is faster in the home environment than in the rehabilitation centre (Participants 2, 5-7).

4.3 Factors Influencing Acceptance of Technology-enhanced Speech and Language relearning for stroke survivors – A systematic review

4.3.1 Summery

In combination with Article 1, this literature review provides insights about related work for the overall thesis. The study highlighted and discussed the major factors that might influence the adoption and technology acceptance of SLR applications for stroke survivors.

The addressed research question was:

What are the critical factors for the acceptance of interactive software applications to support language relearning after stroke?

97 state of the art articles from 2016 to 2021 were retrieved and studied to answer this research question. 13 high quality (mostly Journal with good impact factor) and most relevant articles were selected for further detailed study.

4.3.2 Main Findings

The selected articles' overviews, methodologies, and major findings are presented in the following table 3. The table is extracted from the main findings of article 3 of this study (Ahmad et al., 2021).

Table 3. Selected articles' overviews and main findings

Author(s), Year, Title, Country	Method, Participants	Findings and Critical factors
Simic, Tijana, et al. (2016). "A usability study of internet-based therapy for naming deficits in aphasia." <i>American Journal of Speech-Language Pathology</i> (Simic et al., 2016) Canada	Usability testing using System Usability Scale (Brooke, 1986), Patients: 6 Clinicians: 2	Aphasia patients mostly are adopting internet-based speech and language therapy; which is more improved and consulted by medical caregivers. Key performance metrics are user satisfaction, patient-clinician interaction, and patients' ability to TES.
Kesav, Praveen, et al. (2017). "Effectiveness of speech-language therapy either alone or with add-on computer-based language therapy software (Malayalam version) for early post-stroke aphasia: A feasibility study." <i>Journal of the neurological sciences</i> (Kesav et al., 2017) India	Quantitative Study Statistical analysis Patients: 24	Digital therapy is the main role player with association to the computers, which focus on patients needs and therapy requirements. Less intensive exercises showed more improvement than highly intensive exercises. More useful and effective software in local and native languages give better results in TES.
Roper, Abi, et al. 2018. "Usability Testing-An Aphasia Perspective." <i>The Proceedings of the 20th International ACM SIGACCESS Conference on Computers and Accessibility</i> (Roper et al., 2018) United Kingdom	Qualitative Study based on semi-structured interviews	Technology acceptance for patient's changing cognitive and physical abilities mainly depends on their involvement in the process of design and development. User-friendly design techniques are playing a significant role in TES acceptance.
Tousignant, Michel, et al. (2018). "Satisfaction with in-home speech telerehabilitation in post-	Quantitative Study based on surveys	Telerehabilitation is important and more convenient for the independent home monitoring process. Consultation and

<p>stroke aphasia: an exploratory analysis." <i>Journal of International Society for Telemedicine and eHealth</i> (Tousignant et al., 2018)</p> <p>Canada</p>	<p>Participants: 20</p>	<p>information from relatives and family members of the patients can be better reports to monitor the patients.</p>
<p>Øra, Hege Prag, et al. (2018). "Telerehabilitation for aphasia–protocol of a pragmatic, exploratory, pilot randomized controlled trial." <i>Trials</i> 19, 208 (Øra et al., 2018)</p> <p>Norway</p>	<p>Randomized controlled trial (RCT), questionnaires and semi-structured interviews Patients: 80</p>	<p>The role of telerehabilitation in aphasia patient's monitoring is emerging these days. Exercises with low intensity are more feasible for tele rehabilitation. The tailor-aware TES are better choices for language-deficit patients</p>
<p>Garcia, Manuel B. (2019). "A Speech Therapy Game Application for Aphasia Patient Neurorehabilitation–A Pilot Study of an mHealth App." <i>International Journal of the Simulation, Systems, Science & Technology</i> (Garcia, 2019)</p> <p>Philippines</p>	<p>Usability testing using System Usability Scale (SUS) Patients: 5 Speech therapists: 2</p>	<p>Social networking and gaming software are the potential and useful components to entertain and keep busy the patients. Desktop computers and mini-Tablets are convenient and useful tools for older adults with impaired eyesight after stroke.</p>
<p>Marshall, Jane, et al. (2019) "Technology-enhanced writing therapy for people with aphasia: results of a quasi-randomized controlled study." <i>International journal of language & the communication disorders</i> (Marshall et al., 2019)</p> <p>United Kingdom</p>	<p>Quasi-randomized wait-list controlled design Patients: 21</p>	<p>Digital assisting technologies, for instance, speech to text conversion software can be helpful to relearn writing skills, so the proper interface is vital. The training and skills development to patients are the main components related to digital technologies for TES.</p>
<p>Ahmad, et al. (2019) "Testbed requirements for technology-enhanced stroke rehabilitation to support independent living"(INSTICC Press, 2019.) (Ahmad et al., 2019b)</p> <p>Sweden</p>	<p>Design science Medical caregivers: 5</p>	<p>TES empowers the independent and better life to patients, also security and privacy are alarming entities while considering the technological trends and practices.</p>

<p>Ahlin, et al. (2019) "Determining Testbed Requirements for Technology Enhanced Speech Rehabilitation after Stroke-the Informed Co-workers' View Point." <i>IARIA GLOBAL HEALTH International Conference on Global Health Challenges</i> (Ahlin et al., 2019)</p> <p>Sweden</p>	<p>Design science</p> <p>Participants: 10 Speech therapists: 2</p>	<p>For TES speech and language relearning there should be distinct practical exercises with convenience and ease. Besides, close relatives and friends and contacts of the patients can give detailed information about TES for patients.</p>
<p>Mallet, Karen, et al. (2019) "RecoverNow: A patient perspective on the delivery of mobile tablet-based stroke rehabilitation in the acute care setting." <i>International Journal of Stroke</i>. (Mallet et al., 2019)</p> <p>Canada</p>	<p>A quantitative study, open text response engagement survey</p> <p>Patients: 30</p>	<p>Stroke patients tend to use mobile tablet-based for relearning communication skills, however, technical assistance and education to get better access to TES necessary to be sought.</p>
<p>Lavoie, et al. (2019) "Efficacy of a self-administered treatment using a smart tablet to improve functional vocabulary in post-stroke aphasia: a case-series study." <i>International journal of language & communication disorders</i> (Lavoie et al., 2019)</p> <p>Canada</p>	<p>Multiple baseline single-case series using ABA design</p> <p>Patients: 4</p>	<p>Smart and wearable devices have made the lives of healthcare specialists easier and convenient for example, expert therapists and patients. So, digital technologies are the main entities for better improvements and enhanced results.</p>
<p>Wu, D. (2020). Use of an Internet-of-Things Smart Home System for Healthy Aging in Older Adults in Residential Settings: Pilot Feasibility Study. <i>JMIR aging</i>, 3(2), e21964 (Wu, 2020)</p> <p>USA</p>	<p>Feasibility study</p> <p>Participants: 37</p>	<p>The use of wearable devices is the main supporting entity for elderly patients for cost-effective and continuous monitoring of their health conditions. Sensor-driven technologies are well-equipped with required needs, for instance, smart speakers, windows and door sensors, humidity and temperature sensors, cameras for the well-being and efficient monitoring of the patients.</p>

<p>Vaezipour, et al., (2021). “It’s really exciting to think where it could go”: a mixed-method investigation of clinician acceptance, barriers and enablers of virtual reality technology in communication rehabilitation. Disability and Rehabilitation (Vaezipour et al., 2021)</p> <p>Australia</p>	<p>Semi-structured interviews and survey</p> <p>Participants: 15</p>	<p>Virtual reality (VR)-enabled applications are the revolutionary paradigms in facilitating speech therapists and stroke patients. These days most of the systems for online training and analysis are well-equipped with the required needs and standards. Less prior knowledge and hindrances keep the users away from technology due to the fear and complications in usage.</p>
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4.4 Technology acceptance of an online aphasia assessment application for stroke patients

4.4.1 Summery

The speech and language relearning process starts with an initial assessment/diagnosis of language impairments. The old paper pen-based system consists of a set of exercises that are performed in a rehabilitation system. To facilitate the patients and the speech therapists, the manual paper-pen based assessment system was converted into an online software application. This study evaluates technology acceptance and adoption of this application for speech therapists.

The research question was formulated as: *What is the technology acceptance of speech and language assessment application for medical caregivers?*

Six stroke therapists including three speech therapists participated in the study. An evaluation focused design science approach was used to answer this research question, and the UTAUT model was used as theoretical knowledge. The application was useful and user friendly from the speech therapists’ viewpoint; however, this is an early evaluation of the applications and still, a more detailed discussion is required after including stroke patients. It is analysed that all the functions of the application should be designed and developed in close collaboration with speech therapists and the patients, and the application must be compatible with the already existing systems and their work routines.

4.4.2 Main Findings

The major findings were categorised and presented according to the UTAUT model’s technology acceptance elements such as performance expectancy, effort expectancy, social influence and facilitating conditions. However, considering the diverse comments from the study participants, trust (in regards to user’s privacy and data security) and user’s previous knowledge and experience were added as extra categories.

All the speech therapists acknowledged the effectiveness and usefulness of the application (Participants 1-3, Table 2). They also highlighted and suggested some important issues that must be addressed for better adaptability and acceptance of the technology.

The automated evaluation function in the application was the main determinant for performance expectancy (Participants 1-3, Table 2). As presented in Figure 11, the application automatically generates interactive and meaningful graphs, which was not possible with the old paper-based

system. Each graph represents a speech and language impairment category such as informative speech, repetition, listening and writing and so on. The patient's performance and impairments level is presented with help of an informative colour scheme; the green colour presents a good performance of patient, the yellow colour presents a medium level of disability, and the red colour shows some major disabilities that need to be focused more.

A-ning ÖVERSIKT-SPRÅKLIG FÖRMÅGA

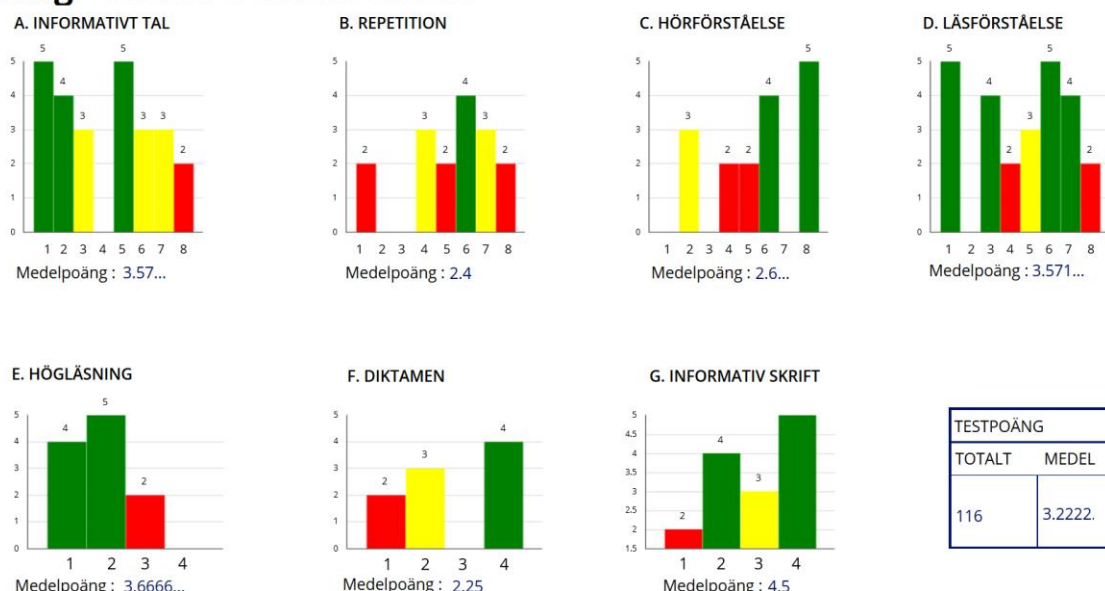


Figure 11. Speech and language impairments assessment

The following citations from the interviews with speech therapists and their critical analysis gives us an overview of the main findings of the study.

Speech therapist 1 (Study Participant 1, Table 1)

“The manual assessment 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; this auto-generated evaluation will help me in my daily routine work. However, the application should be automatically connected with the hospital’s existing journal system.”

The old paper and pen based speech and language assessment system takes a lot of time to calculate the assessment points manually. After a session with the patient, the speech therapists have to do several calculations for diagnosing the patient’s impairment level. Thereafter, they transfer the gathered data to the hospital journal. Since the suggested online application makes these calculations digitally, it might be easy for speech therapists to transfer the patient's data to the hospital journal. Speech therapist 1 suggested that the application should be automatically connected to the hospital journal system so that manual data entry into the journal system could be avoided.

Speech therapist 2 (Study Participant 2, Table 1)

“The system is easy to use, interactive and self-descriptive; I can perform the tasks without any help or guidance. However, all the sub-tasks need more tailor-made alterations to synchronise the system with the existing system.”

Speech therapist 2 used the application for the first time and it was easy for her to navigate throughout the entire process. She was able to perform the functions easily without any help or guidelines; however, she emphasised better synchronization with the workflow of the existing system. For example, the sub-tasks in each exercise should be designed according to the previous paper and pen based system. In a later interview, speech therapist 1 also that the application should be altered to fit their daily work routines.

Speech therapist 3 (Study Participant 3, Table 1)

“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.”

In the existing paper and pen based system, the sequence of performing the exercises is different than the categorization of exercises for the final presentation which makes it difficult to calculate the evaluation points. Since the new system makes the calculation automatically and the speech therapist do not have to do it manually, it might ease their job. However, the same sequence of performing the exercises and calculating the points might increase the ease of use of the application. Speech therapists 1 and 2 also suggested; there should be separate folders for different categories with descriptive names and all the exercises related to the same category should be presented in its dedicated folder. Hence, it will be easy for them to manage and conduct the test.

An early user’s participation in system development and design also plays an important role in the technology acceptance of that system. During the interviews, it is observed that the speech therapists 2 and 3 who were involved earlier (from the requirements identification phase), showed more interest and intention to use the system as compared to speech therapist 1 who participated only in the evaluation of the developed application.

5 Discussion

This chapter presents the discussion about overall research contributions and their relation to other similar studies. Thereafter, methodological and ethical considerations in different regards are discussed. Finally, the study limitation and the possibilities of future research are discussed.

5.1 Research Contributions

The primary aim of this study was to identify and understand the users' needs for technology-enhanced speech and language relearning after stroke. Both the speech therapists and stroke patients were the potential users in this study context. The overall requirements were collected from different important stakeholders involved in stroke rehabilitation. Medical therapists such as speech, occupational and physiotherapists played an important role in understanding the users' requirements for technology enhancement. The adult learning theory provided a good theoretical ground for analysing the requirements for stroke survivors' relearning.

The secondary aim of this study was to evaluate the technology acceptance of a speech and language assessment application for medical caregivers. The three speech therapists participated in the evaluation process. The technology acceptance is evaluated according to the UTAUT elements: performance expectancy, effort expectancy, social influence and facilitating conditions. The general requirements for technology acceptance for the application were the same as discussed above as the primary aim of the study, "user's requirements for technology-enhanced speech and language relearning". However, the specific functions in the application that might affect the technology acceptance are discussed from the UTAUT model lens. Both the user's requirements for technology-enhanced speech and language relearning and technology acceptance are discussed in the following text.

All the study participants emphasised the tailor-made solutions according to the patient, cognitive and physical disabilities after stroke. Previous research on SLR also highlighted the same phenomena (Kesav et al., 2017; Rybarczyk and Fonseca, 2011; Simic et al., 2016). Impaired focus and low concentration levels are common in stroke patients; therefore, the intensity of relearning therapies should be according to the patient's focus level (Kesav et al., 2017). The study participants emphasised the low intensive and short intervals of exercise for the patients with impaired focus. Therefore, the SLR application should have functionality to adjust exercises according to the patient's medical condition. The speech therapist should be able to change the span and intensity of exercise before or during the session with the patient. As Knowles et al. (2014) suggested in adult learning theory, every person is different and he/she needs an individualised plan for their learning.

Since the SLR process starts with an initial evaluation of the patient's language impairments, the online application for speech assessment was suggested by the speech therapists. That application was co-created in close collaboration with speech therapists. The application gives a quick and interactive overview of the patient's current impairment level which not only lessens speech therapist work but also makes it easy to discuss the results with the patients so that they can be involved in their relearning process.

The need for an individualised plan for patients' relearning motivates a user-centred design strategy, where user empowerment must be the main priority. All the stakeholders should be involved in software design and development. The adult learning theory also suggests that adult people like to get involved in the planning of their learning strategies. The importance of UCD is discussed in several previous studies (Ahmad et al., 2019b; Dabbs et al., 2009; Simic et al., 2016); however, close

collaboration with the users, becomes even more significant when you deal with patients who have different levels of impairments.

The study also revealed the importance of patient's close relatives and friends in their journey towards dependent living after stroke. Physically and cognitively impaired patients feel comfortable with their close ones, and they tend to get help from the people living with them (Garcia, 2019). Some extra functions in the application that enable the patient's relatives and friends interaction would be a great help for speech therapists, patients and their patients' relatives and friends. In this way, they can participate in the therapy sessions and interact with patients and speech therapists simultaneously.

The relationship between a user's personality and his/her behavioural intentions to use a given technology is complex and it depends upon several different factors. Such factors are, among others, trust in personal data security, personal integrity and privacy, previous experience with technology, and the willingness to learn the new technologies. Moreover, the developed systems must be in line with the social needs, highly compatible and flexible with clear guidance and coherent technology involvement (Venkatesh et al., 2016).

5.2 Methodological Considerations

The design science research approach(DSR) is a useful strategy to understand a real-world problem by developing artefacts and analysing their impact on the real world (McKay and Marshall, 2007). As addressed by Hevner et al. (2004), the creation of innovative artefacts may lead to a better understanding of the real-world problem. DSR was adopted because the basic aim of this research was to solve a real-world problem by developing a software application.

Design science is very supportive to provide a framework where different research methods and theories can be applied and integrated in unique ways (Hevner et al., 2004; Johannesson and Perjons, 2014). To find an optimal solution to a research problem, mixed methods are common in the information systems and computer science domains (Johnson et al., 2007). Several tools and techniques for evaluation of the artefacts are suggested by Hevner et al. (2004). Therefore, various research methods and theories were used to achieve the objectives during different activities in the DSR process. For example, the adult learning principles and Unified Theory of Acceptance and Use of Technology (UTAUT) were dedicated for user requirement identification and evaluation, respectively.

Qualitative research methods provide a deep understanding of subjective opinion and narrative (Vanderstoep and Johnson, 2008) and the aim of this study was also to understand the users and their needs for technology enhancement. Therefore, interviews, observations and thematic analysis were conducted for proper data collection and analysis.

5.3 Ethical Aspects of the Study

Ethics are of utmost importance for effective research. The effects of research on the research participants should be considered strongly from an ethical point of view (Helgesson, 2015). In all the included research articles, guidelines and rules from the Swedish Research Council(CODEX) were followed for ethical aspects (Eriksson, 2015). According to CODEX (2015), well-informed consent should be considered as one of the important ethical aspects. All the research participants must be informed about their rights to know the purpose of the research and to decide about their participation in the study. Therefore, a detailed briefing about participants rights regarding the interview was given to all the study participants.

The anonymity and privacy of the study participants should also be carefully ensured (Hewson and Buchanan, 2013b; Kvale et al., 2014). The basics principles of data privacy and personal integrity are

the same in human research ethics, however, the researchers should be more careful while conducting interviews online (Hewson and Buchanan, 2013a; Jowett, 2020). The participants were informed that personal data e.g. their names will not be disclosed in the research articles and reports. All the interviews were audio-recorded and stored securely at the university database that can only be accessed by the research participants.

Since the research is conducted during a global pandemic (Covid-19), there are special ethics to consider for interviewing people. The well-being and overall health of study participants should always get priority over the research objectives and timelines (Jowett, 2020). Therefore, all the recommendations and rules were followed to avoid the Covid-19 spread. The interviews were conducted online where it was possible. However, to avoid unnecessary stress on the participants due to the lack of digital literacy and to observe testing scenarios properly, some of the interviews were conducted face-to-face. Particularly, medical professionals tend to get stressed and they might perform differently during online interviews (Jowett, 2020). To provide better conditions and a friendly environment, one of the researchers was available at the interview place while the other two researchers participated online during the interview.

To develop a healthy and pleasant work environment, close and friendly collaboration with the participants is also of great importance. The study participants should feel comfortable, secure and satisfied during the interviews (Dahlbom and Mathiassen, 1994; Hewson and Buchanan, 2013a). Therefore, open discussions and semi-structured interviews were conducted in a friendly and pleasant environment. During the study, it is observed that a general discussion with the participants about their expertise and interests creates a pleasant, positive and healthy relationship between the researchers and study participants.

5.4 Study Limitations and Future Work

Every study has some limitations which usually provide the researchers with a direction towards future work. The research limitations describe the circumstances or situations that might affect the overall study aim and expected results (Baron, 2008; Simon, 2011). Sometimes, such situations occur after the study aim is defined, hence they affect the study aim as well (Baron, 2008). Usually, these circumstances cannot be controlled by the researcher (Simon, 2011). One such situation occurred due to the Covid-19 pandemic; considering the safety and wellbeing of the patients, they could not be involved in the requirement gathering and application development phase except for one patient. The chairman of the local stroke patient organization (Participant 8) who is also a stroke survivor gave some good insights into the patient's needs. The literature review on recent qualitative studies also provided some good understandings of patients' participation in technology-enhanced speech and language relearning (Ahmad and Mozelius, 2020; Mozelius et al., 2019). However, the patients' perspective is of utmost importance and in future research more patients should be involved to enable their strong participation and empowerment. The literature review on technology acceptance (Article 3) emphasised further research on the adoption and usability of the technology-enhanced systems for patients with impaired physical and mental conditions as well as for medical caregivers such as speech therapists (Ahmad et al., 2021).

6 Conclusion

The study established an in-depth understanding of medical caregivers and stroke patient's need for technology-enhanced speech and language relearning. The requirements for technology enhancement are highlighted from the most relevant medical professionals' viewpoint. A collaborative effort from patients, their significant others and speech therapists is of great importance for the successful use of technology-enhanced systems. Therefore, their participation and empowerment should be ensured while design and developing these systems. However, the patient's ability to use a specific technology heavily depends upon the patient's physical and cognitive health after stroke.

Due to post-stroke disabilities such as impaired vision, upper limb motor impairment, and a shorter attention span, the patients have some specific hardware and software requirements. They need a bigger screen size of hardware, preferably a tablet with touch pen or a desktop computer with a touch screen. In order to provide a customized solution for the patients, the SLR application should be platform-independent so that it can be installed on suitable hardware according to the patients' medical conditions. The GUI should also be customized and adjustable according to the patients' needs. For example, a bigger typography size, constructive colour scheme between completed and uncompleted tasks, and a simple background (without any pictures and attractive themes to avoid distractions) are preferred for patients.

The user's requirements were successfully aligned with the adult learning principles. Knowles's Andragogy In practice Model gives a comprehensive framework to establish stroke patients' relearning objectives. Since adults like to be involved in designing their relearning process, one important requirement suggested by the study participants and motivated by the adult learning theory, was to convert a speech and language assessment tool that allows instant and easy interaction with the patients. The application was co-created and tested for technology acceptance with the speech therapists.

The technology acceptance evaluation reveals that the application is useful and efficiently useable for speech therapists. The automatically generated diagnosis system not only lessened the speech therapists workload but it also provided an instant tool to discuss their impairments with the patients. On the other, the functionality of online treatment will provide a better quality of life and independent living to the patients and their close relatives. However, the study revealed some critical factors for better technology acceptance and adoption of the application. To enhance usability and usefulness for speech therapists, the application should be properly synchronised with the existing system in place. All the tasks and sub-tasks in the application must be aligned with the existing workflow and they should be designed and developed in close collaboration with speech therapists.

The intention to use the technology also depends upon an early user's participation in system development and design. The speech therapists, who participated from the start, showed more interest to use the system as compared to the participant who was only involved in the technology acceptance evaluation. Therefore, the user's thorough participation and empowerment is of utmost importance for a useful and useable technology-enhanced system.

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APPENDIX I

Requirements for the development of an interactive speech and language assessment application

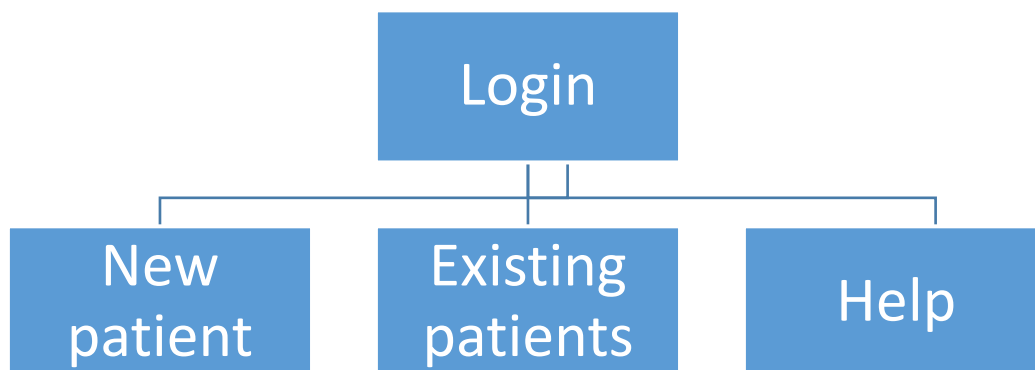
The requirements are divided into functional and non-functional requirements. Functional requirements describe the functionality or services of the software while the non-functional requirement explains the performance characteristics of the software. In other words, functional requirements elaborate on what software will do, and non-functional emphasis on how the software will do so.

Functional requirements

The functional requirements are different for the speech therapist from the patients because the patients' pages in A-Ning are different from the therapist pages, moreover, some extra management functionality for speech therapists is needed so that they can adjust the tasks according to the patient's condition.

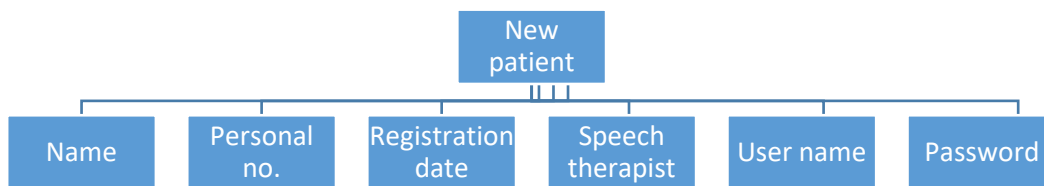
Functional requirements for speech therapist

After logging in to the application, the speech therapist should be able to create a new patient account and manage the existing patients. The help function will be available throughout the interface in all the stages.



- **New patient**

The speech therapist will create a new account by giving the following information as described in the figure below.



- **Existing Patients**

The “existing patients” page contains a list of all the registered patients. The initial information on this main page will be the patient’s name, user name, and registration date as illustrated in the following figure.

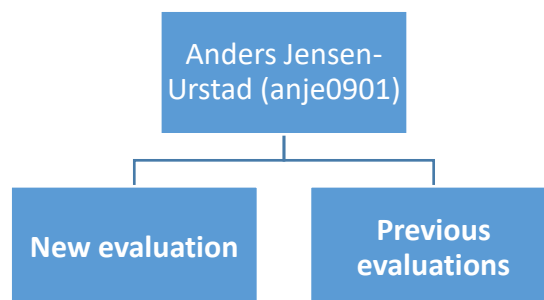
```

graph TD
    EP[Existing Patients] --- Table
  
```

Name	Registration date
Anders Jensen-Urstad (anje0901)	2019-06-21
Andreas Moe (anmo1602)	2019-08-01
Brandur Eysturoy (brey1800)	2019-02-15
Caroline Engqvist (caen1500)	2020-04-20

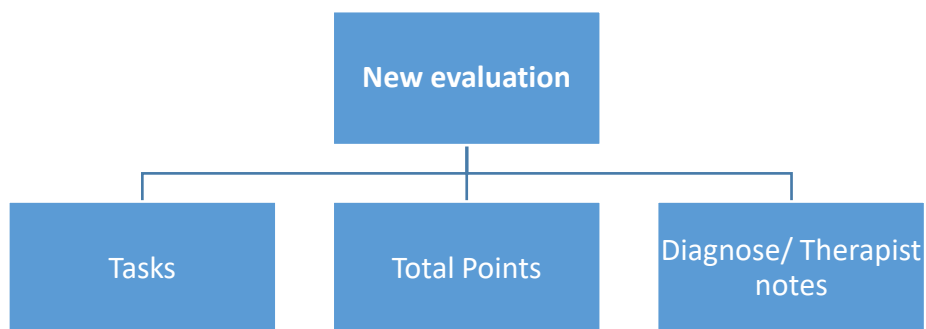
A diagram showing a box labeled 'Existing Patients' connected by a line to a larger box containing a table with patient information.

For each patient, the therapist should be able to perform a new assessment or look into a previous assessment.



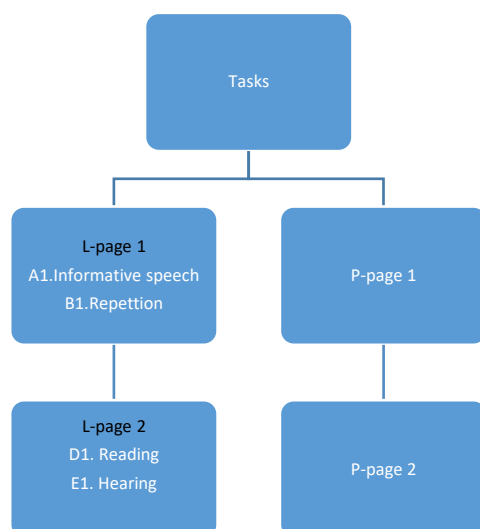
- **New assessment**

For the new assessment’s main page, tasks, total points, and the written notes or comments will be presented. The “Tasks” function is described in the upcoming headline. Total points are the points that are achieved in all performed tasks. These points provide a base for speech and language diagnose. “Therapist notes” will provide the therapist a writing box to write notes about qualitative information and diagnosis such as observations during the assessments.



- **Tasks**

“Tasks” is the main page to start an assessment process. It will contain both patients pages (P-pages) and therapist pages (L-pages). The L-pages button describes some short information about the task so that the therapist may easily select the task by just looking at the button. All tasks will be presented in a logical order as suggested by “A-ning”. The speech therapist should be able to select the tasks according to the patient’s condition. An example of a patient page and speech therapist page is shown in Figures 1 and 2.

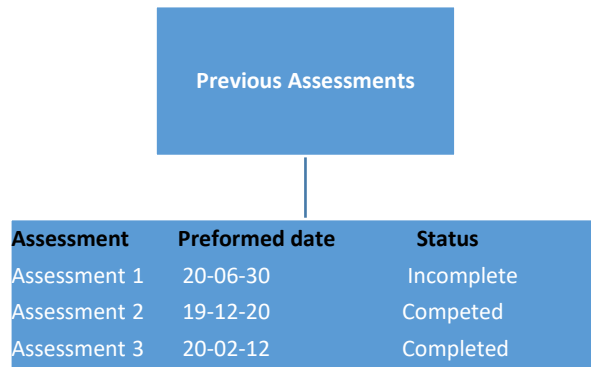


Previous assessments

In the “Previous Assessments” option, a list of previously conducted assessments, their performed date, and current status will be presented.

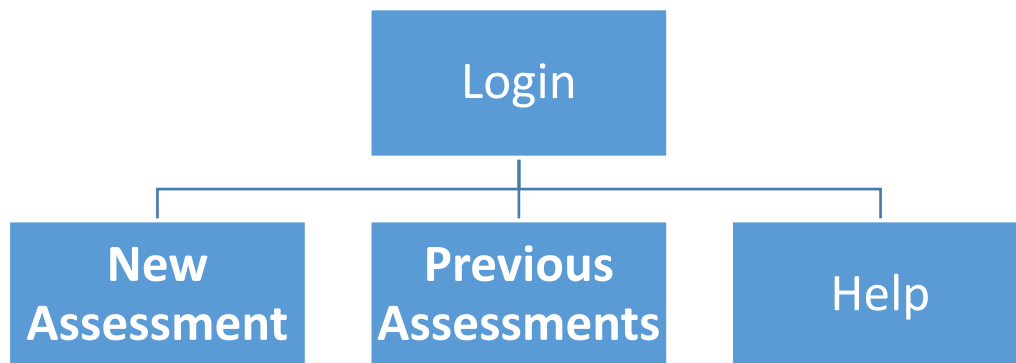
Completed assessment: Previously performed tasks, achieved assessment points, and speech therapist notes should be saved to the completed assessment.

Incomplete status: Sometimes the patient’s medical condition doesn’t allow to perform all the assessment tasks such as the patient’s focus level is not intact. Therefore, the speech therapist needs to conduct the assessment in several sessions. The speech therapist should be able to save an incomplete assessment and resume it later. Previously performed exercises, achieved points, and notes should be saved to an incomplete assessment.



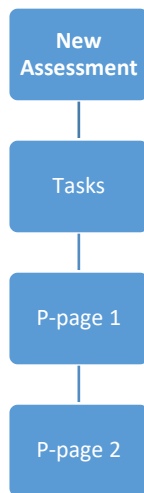
Functional requirements for patient

In principle, all the functionality for the patient will also be presented in the speech therapist interface. However, the patient's interface will be simpler with lesser functions. The main page for the patient will consist of the new assessment, previous assessments, and help options. The help function is discussed in the non-functional requirements section.



New assessment

In the new assessment, a list of all tasks will be provided to the patient and the therapist will guide the patient throughout the process.



Previous assessments

In the previous valuation option, a list of previously conducted assessments, their performed date, and current status will be presented. The patients should be able to see a previously completed or incomplete assessment. Previously performed exercises, achieved assessment points, and comments from the therapist should be available for the patient. The achieved points and therapist's comments may look irrelevant for the patients, however, the motivation comes from the adult learning perspective. The adults need to know their learning progress throughout the process. An initial evaluation of impairments will allow them to see their relearning journey.

Previous Assessments		
Assessment	Preformed date	Status
Assessment 1	20-06-30	Incomplete
Assessment 2	19-12-20	Completed
Assessment 3	20-02-12	Completed

Non-functional requirements

Non-functional requirements focused on the aspects that were critical for the efficiency, usefulness, and acceptance of the software. Some of the requirements are also motivated by the literature review conducted in the previous course.

Native language

The software application should be in the native (Swedish) language or there should be an option to choose a language. The speech therapists highlighted that most of the available software for speech are available in the English language, however, the therapy should be conducted in the native language. The Head of the local mobile stroke team highlighted that the number of immigrants with different

languages is increasing in Sweden so the number of stroke patients is also expected to increase, therefore, the option of selecting different languages in the software is preferable. However, due to the time constants, this software will only be available in one language (Swedish).

Hardwar

The application should be platform-independent, and it should be compatible with different kinds of hardware. A stroke survivor's ability to use hardware also depends upon his physical condition, therefore, the software should be usable on different types of devices such as smartphones, tablets, and computers.

Graphical interface

The requirements for the interface are related to the usability aspects of the software. These requirements came from the previously conducted literature review. The interface should be adjusted according to stroke patients' needs. For example, the typography size should be bigger than usual and the background should be simple to avoid distraction. Ideally, the font size should be adjustable and the background themes should be changeable. Moreover, the colours should be more contrastive between selected and unselected items on the screen.

Help function

The help function should contain all the information and instruction that might be helpful for speech therapists and patients. The content of this function will be written incorporated with therapists after the software is developed.

Online assessment

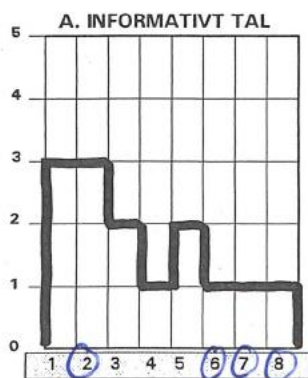
The possibility of online assessment is also discussed with speech therapists. However, a built-in video conference function might be difficult for this study due to time and financial constraints. An alternative option will be to use third-party software such as Skype for an online assessment. This functionality will be discussed more in an upcoming study with the speech therapists.

APPENDIX II

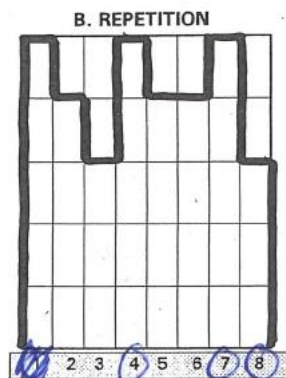
The paper-pen based manual speech and language impairment evaluation.

A-ning ÖVERSIKT - SPRÅKLIG FÖRMÅGA

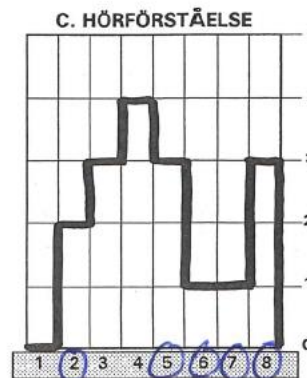
TESTPOÄNG	
TOTALT	MEDEL
84	1,9



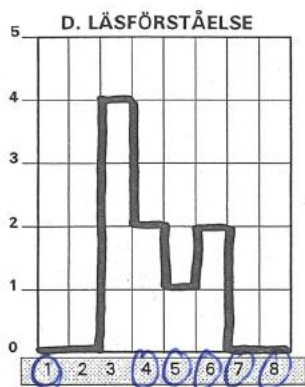
MEDELPOÄNG **1,8**



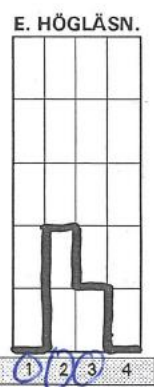
MEDELPOÄNG **4,1**



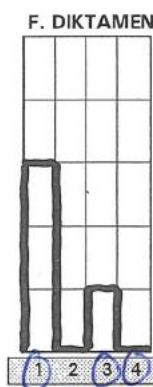
MEDELPOÄNG **2,1**



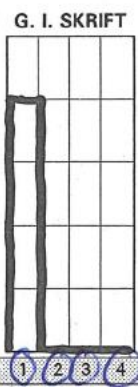
MEDELPOÄNG **1,1**



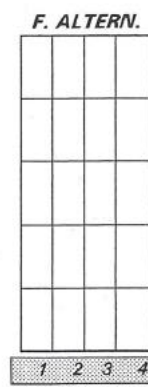
MP. **0,8**



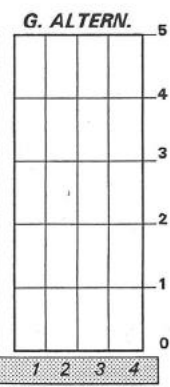
MP. **1,0**



MP. **1,0**



MP. _____



MP. _____

APPENDIX III

Speech and language assessments Application- Speech therapists' Interface

Step 1: Patient's information

←

A-ning

↺

🏠

Ny Patient

Förnamn

EfterNamn

Personnummer

Logoped

Afasitest pågår

☒ På

Skapa

Alla Befintliga Patienter

Erik	Ström			
02/11/2020 22:22				
Anna	Persson			
02/11/2020 15:43				
Awais	Ahmad			
02/11/2020 22:49				

Översikt

Förnamn

Erik

EfterNamn

Ström

Personnummer

198111150000

Logoped

Erika

Afasitest pågår

På

TESTPOÄNG	
TOTALT	MEDEL
116	3.2222...

Step 2: Patient's speech and language impairment diagnosis

←

A-ning

🏠

Förnamn

Erik

Efternamn

Ström

Personnummer

198111150000

Logoped

Erika

Afasitest pågår

☒ På

Uppdatera

Ta bort

A1. Namn, adress, ål...

☐ Av

➔

A1

5

A2. Benämning av bil...

☒ På

➔

A2

4

A3. Benämning efter ...

☒ På

➔

A3

3

A4. Satskomplettering

☐ Av

➔

A4

0

A5. Automatiserade ...

☒ På

➔

A5

5

A6. Meningar

☒ På

➔

A6

3

A7. Beskrivande tal- ...

☒ På

➔

A7

3

A8. Berättande tal- F...

☒ På

➔

A8

2

B1. Bokstäver

☒ På

➔

B1

2

B2. Bokstavssekvenser

☐ Av

➔

B2

0

B3. Nonsensstavelser

☐ Av

➔

B3

0

B4. Ord

☒ På

➔

B4

3

B5. Ordsekvenser

☒ På

➔

B5

2

B6. Ordpar

☐ Av

➔

B6

4

Step 3: Patient's speech and language impairment diagnosis- example of a specific exercise

←

A-ning

🏠

A7. Beskrivande tal- Tematisk bild

Beskrivande tal — Tematisk bild

Visa P-sida 17!

Patienten ska göras uppmärksam på detaljerna om de inte be-
skrivs bild spontant. Cirka tio händelser kan beskrivas med me-
ningar i valfri ordning. En sammanhängande berättelse förvän-
tas ej.

Beskriv den här bilden. Tänk dig att jag inte ser den.
Berätta vad som händer?

komentarer



Poäng

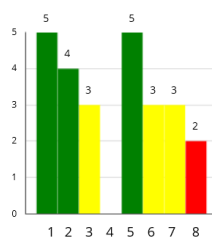
3

Skicka in

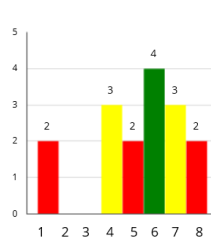
Step 4: Patient's speech and language impairment evaluation

A-ning ÖVERSIKT-SPRÅKLIG FÖRMÅGA

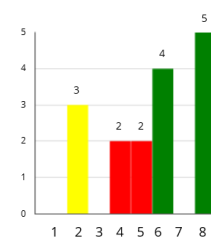
A. INFORMATIV TAL



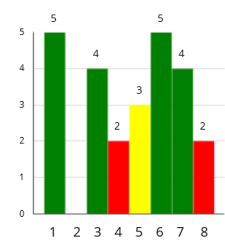
B. REPETITION



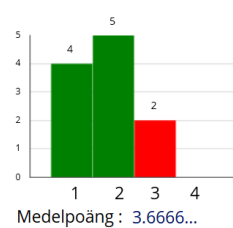
C. HÖRFÖRSTÅELSE



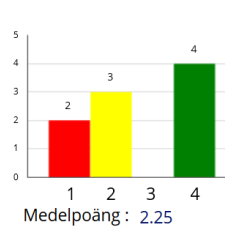
D. LÄSFÖRSTÅELSE



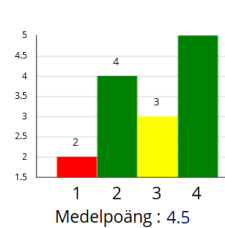
E. HÖGLÄSNING



F. DIKTAMEN



G. INFORMATIV SKRIFT



TESTPOÄNG	
TOTALT	MEDEL
116	3.2222

Speech and language assessments Application- Patients' Interface

<

Patient Sidor

>

Patient sida 1

Patient sida 2

Patient sida 3

Patient sida 4

Patient sida 5

Patient sida 6

Patient sida 7

Patient sida 8

Patient sida 9

Patient sida 10

Patient sida 11

Patient sida 12

Patient sida 13

Patient sida 14

Patient sida 15

Patient sida 16

Patient sida 17

Patient sida 18

Patient sida 19

Patient sida 20

Patient sida 21

APPENDIX IV

Evaluation Tasks of A-ning application

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

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

Task 3

Describing the evaluation

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

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

Task 5

Resuming a previously started evaluation

Technology acceptance Interview questions

Question 1.

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

Question 2

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

Question 3

What are your recommendations to improve the interface?

Question 4

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

Question 5

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

- Infrastructure
- Education/training

On the Importance of Tailor-made Speech Relearning Software for Stroke Rehabilitation

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Keywords: Speech Relearning, Stroke Rehabilitation, User-centred Design, Independent Living, Older Adults.

Abstract: Post stroke rehabilitation is a global issue with increasing challenges today when the percentage of older adults is increasing. There is a need for new solutions to better assist stroke survivors' normally long way back to a good and independent life. The various post stroke impairments can be divided into the categories of cognitive, motoric and speech impairment, and the three also have their interrelations. This position paper has a focus on rehabilitation of stroke survivors' speech impairments, and the use of technology-enhanced systems to assist the speech relearning. The current reuse of language learning software for primary school students is doubtful, and should better be replaced by tailor-made and adaptable tools that fit the target group. Finally, the recommendation is a long-term strategy where some initial costs should fund the design, development and evaluation of new digital tools for speech relearning. This should be conducted in a collaboration between researchers, speech therapists, stroke patients. The approach should be iterative and user-centred, with both speech therapists and stroke patients as the end-users.

1 INTRODUCTION

Stroke is a major cause of disabilities in adults where a stroke survivor may suffer from long term physical and mental impairments (Palmcrantz et al., 2017). Due to a rapidly increasing percentage of older adults all over the world, age-related chronic diseases are also increased and stroke is one of those diseases (Ahmad et al., 2019). It has some serious impacts on the patient's overall daily life activities and often, the friends and family of the patients are also affected (Mozelius et al., 2019). Stroke impairments and their rehabilitation are generally divided into speech, motoric and cognitive disabilities (Ahlin et al., 2019).

This position paper focuses on speech impairments and the use of technology-enhanced systems to perform different types of rehabilitation exercises. After the stroke, patients' ability to read, write, speak and listen can be decreased (Tousignant et al., 2018). Consequently, patient's social and professional life is deeply affected and usually, they fail to continue their professional work and social activities that may lead them to an isolated and depressed state of mind (Ahmad et al., 2019).

Intensive and long-term rehabilitation is needed right after the stroke that involves different kinds of

therapies and exercises (Palmcrantz et al., 2017). However, the human and financial resources needed for the rehabilitation after stroke are not enough in the hospitals and rehabilitation centres (Zhang et al., 2016). The compromised independent life of stroke survivors is also an issue with traditional speech rehabilitation therapies where patients need to stay in the rehabilitation centres for a long time. Recent studies highlighted that living independently in the home environment has some positive impacts on the patient's health condition and the process of healing becomes faster and more effective (Christophorou et al., 2016, Ahlin et al., 2019). Different types of technology-enhanced systems (TES) such as software applications to perform relearning exercises can be useful in this context (Ahmad et al., 2019).

However, several studies highlighted that acceptance of TES also has some critical factors that need to be addressed such as trust, e-health literacy, personal integrity and usability (Ahmad & Mozelius, 2019, De Veer et al., 2015). Another critical factor that has got less attention is the lack of tailor-made software solutions for speech learning with a design that builds on the target group's special needs. Speech therapists today, frequently use software applications that are developed for primary school students in the relearning process for older adults (Ahlin, Ahmad &

Mozelius, 2019). In this position paper authors argue for the importance of speech relearning software that is tailor-made for stroke survivors. Arguments have been gathered in a mix of a literature study, and from personal reflections on earlier studies on stroke rehabilitation.

2 STROKE REHABILITATION

A stroke patient's way back to a joyful life and independent life after stroke is a long and tedious journey, where patients and relatives have to struggle hard for a successful relearning of earlier skills and knowledge (Greveson & James, 1991; Broeren et al., 2008). The various impairments can be divided into the categories of cognitive, motoric and speech impairment, where the cognitive part of the rehabilitation has a clear relation to both the motoric and the speech relearning aspects of stroke rehabilitation (Ahmad, Mozelius & Ahlin, 2019).

Motoric rehabilitation deals with problems using various body parts, while speech rehabilitation is related to language and communication issues. Both these impairments can severely the ability to read, write, communicate and also stroke patients' cognitive capacity (Seniów, Litwin & Lesniak, 2009, Veerbeek et al., 2014, Pollock et al., 2014, Toussignant et al., 2018). All three types of rehabilitation ought to be based on an active everyday treatment schedule, which could be challenging to provide due to the cost of specialised therapists. An effective alternative to the traditional long-term rehabilitation could be the use of various TES. However, if a TES based relearning should be successful and effective there must be high quality standards for both usability and for a design that is appealing to the target group.

3 SPEECH RELEARNING

Speech and language impairments are very common after stroke, and one out of three stroke survivors suffer from these disabilities (Tousignant et al., 2018, Greener et al., 1999). People with these impairments face immense challenges in communication as their capabilities to speak and listen are affected. The intensity of these deficiencies may vary from patient to patient where some people can understand and speak a few words only, while others can communicate almost fluently with some minor problems (Egaji et al., 2019).

After the stroke, the relearning process of speech skills has always been challenging for patients and medical caregivers. A patient needs to perform relearning exercises that can be very difficult with an already impaired physical condition and medical caregivers have to spend a lot of time in order to help the patient with those exercises (Ahlin et al., 2019). To achieve better efficiency and fast recovery, these interventions are recommended to start as soon as possible after the stroke (Ahmad et al., 2019).

After an initial examination and treatment at the hospital, the patients are usually referred to the rehabilitation centre, where the speech therapists make a long-term or a short-term relearning plan depending on the patients' level of disability (Egaji et al., 2019). Several studies showed that intensive and long-term therapy is needed for an effective relearning of speech and language skills (Øra et al., 2018). However, the resources needed for that kind of intervention are not enough in the rehabilitation centres and the speech therapists complain that they do not have enough time for the required therapies of an increasing number of patients (Ahlin et al., 2019). Technology-enhanced relearning exercises can play a vital role in this context.

The use of technology in different types of rehabilitation processes has been discussed for almost last two decades and these technologies have shown some potential benefits such as better accessibility, improved quality of life, possibilities of independent living and healthier social life (Zhang et al., 2016, Tousignant et al., 2018, Rizzo and Kim, 2005). However, the implementation of these technologies has certain challenges that need to be addressed. One challenge is the lack of adaptability and interest in technology, especially the older population who are not grown up with computers and smartphones seem not to be comfortable with the use of software applications (Ahmad and Mozelius, 2019). The use of new tools is always difficult for people who already face the communication problem due to speech and language deficiencies (Simic et al., 2016). In order to make TES accessible and useable for the patients, they should be actively involved in the development process (Roper et al., 2018).

4 THE IMPORTANCE OF TAILOR-MADE SPEECH RELEARNING SOFTWARE

As for all other tools used for rehabilitation, it is of great importance that TES solutions for speech relearning are tailor-made for the target group. There are today few digital speech relearning tools available

that are based on both stroke survivors' and speech therapists' needs. Furthermore, the TES tools should better also have built-in adaptability to meet the stroke patients' individual needs

A user-centred design and development seems essential, with a dual focus on both stroke patients and speech therapists as users. Some examples from the speech therapists' wish list are interactive pictures and video-clips where they can demonstrate the content and the training instructions. The design needs to focus on variation, with content and a graphic design that is relevant for adults and older adults. Another requirement is that the TES tools also should be accessible for patients' relatives and friends, who often play an important role in successful speech rehabilitation after stroke.

The current habit of reusing language learning software for primary school students ought to be broken. This is a short-sighted strategy that in a narrow perspective might save some costs, but goes against the grain of fundamental healthcare principles. At the same time, it can be offending for someone in her seventies to carry out exercises in a game designed for lower primary school. Furthermore, a backstory with exercises related to stroke survivors' daily tasks would also support the rehabilitation alignment between speech relearning and cognitive relearning.

Finally, stroke patients' often limited energy for relearning should better be used on the actual relearning. The software must have user-friendly navigation and intuitive usability, considering the fact that many stroke patients also suffer from visual impairments. This should also include the hardware in TES solutions, where new interfaces on laptops, tablets and mobile phones can be difficult to navigate. What already is in use, and can be further extended is the concept of Bring Your Own Device (BYOD). In a wider definition, BYOD could be described as "the practice of people bringing their own laptops, tablets, smartphones, or other mobile devices with them to learning or work environments" (Johnson et al. 2016, p. 36).

5 CONCLUSION

In light of recent studies on speech and language recovery, this position paper emphasized on the importance of customized digital solutions that are explicitly built according to the patients' current physical and cognitive condition. Since the rehabilitation exercises for speech impairments can be performed in the home environment with the help of tailor-made software applications, patients will be able to live independently and their quality of life will

also be increased. However, these software applications should be user-friendly and patients should feel a sense of enjoyment by using TES. Therefore, a user-centred design approach should be adopted for the development of suggested TES.

6 RECOMMENDATION

Authors' recommendation is a long-term strategy where some initial costs should be spent on design, development and evaluation of TES for speech relearning. This should be carried out in collaboration between researchers, speech therapists and stroke patients. The approach should be iterative and user-centred, with both speech therapists, stroke patients and patients' families and friends as end-users. An interesting add-on feature would be a built-in analysis of each patients' learning progression. Further details for the design and development are described more in detail here below in the next section.

7 FUTURE WORK

The study highlighted the importance of tailor-made software applications to perform exercises for relearning speech skills after a stroke. Naturally, the next step would be to develop the suggested software application. In order to achieve the desired results, a user-centred design approach should be adopted. A typical user-centred design consists of five basic steps: Interviews and observations with different stakeholders, identifying the requirements, gathering the ideas for prototype design, designing and developing the prototype, and usability testing (Dorrington et al., 2016). The requirements should be gathered in collaboration with researchers, software developers, medical caregivers, and the patients for designing an interactive and user-friendly software application.

The role of user experience (UX) designer and/or UX researcher is very important in a user-centered design approach. A UX designer needs to work parallel both with users (patients and speech therapists in the current context) as well as with the software development team (Almughram et al., 2017). Therefore, UX designers should be involved in the process of designing a prototype and the software engineers should work closely with them.

Finally, a comprehensive usability testing should be conducted for the developed software application. The input from the user experience will not only be helpful to increase the ease of use and to provide better interaction with the suggested TES, but it will

also give the researchers a better understanding of the disabilities and limitations of stroke survivors.

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Speech and Language Relearning for Stroke Patients- Understanding User Needs for Technology Enhancement

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Abstract—Speech and language relearning are challenging for stroke survivors, as well as medical caregivers. After a stroke, patient's ability to read, write, speak, and listen is decreased to different degrees, which results in a compromised independent life and a decreased quality of life for the patients. Technology-Enhanced Systems (TES) can play a vital role in this context. However, the available software are not explicitly built for recovering stroke patients' needs but often for children's learning needs. This paper is, therefore, aimed at gathering requirements to support the design of speech and language relearning software applications for stroke survivors. A design science approach was adopted, where different stakeholders such as medical caregivers and information technology consultants were involved in the process. Deductive thematic analysis was conducted to analyze the main findings according to adult learning theory. The software requirements vary from patient to patient where the intensity of speech and language impairments, general medical condition, age, prior experience, and knowledge about the previous health record, and social setup of the patient are playing an important role. The speech therapists should have management functionality in the software to adjust the relearning exercises according to the patient's needs. Since, stroke is most common in adults who learn differently than children, andragogy principles were useful in recognizing patients' health conditions. Adults are interested to be involved in the development of their relearning process. Software for speech and language assessment will be helpful to establish relearning objectives for patients.

Keywords- Requirements specification, E-Health, Stroke rehabilitation, Speech and language relearning, Adult learning theory, Independent living

I. INTRODUCTION

Stroke is one of the most common causes of death and different kinds of chronic disabilities in adults [1]. The

fundamental reason for stroke is a partial or complete stoppage of blood flow to the brain that severely affects the brain function; consequently, the overall human body may face different types of disabilities [2]. A stroke survivor often suffers from several long-term mental and physical impairments that have a considerable impact on the patient's daily life activities [3]-[6]. Disabilities and their rehabilitation following stroke are generally divided into speech, cognitive, and motoric impairments [7]-[10].

This research paper focuses on speech and language disabilities and the role of TES for relearning speech and language skills. Almost one-third of a stroke survivor's ability past learning experiences, to communicate is reduced due to impaired reading, writing, listening, and speaking skills [11]-[15]. Most impairments occur during the first weeks after the stroke, but the rest of the recovery may take several years. A decreased ability to communicate has some severe consequences for the patient. One of the consequences is an unhealthy social life [16]-[20]. The patients' social life deeply affects their quality of life; they seem to lose the pure happiness of life and often they feel isolated from society [21]-[25]. To reduce the potential risk for a patient's depressed mental state, the process of relearning communication skills needs to be started as soon as possible after a stroke. Several studies highlighted the benefits of early interventions right after the stroke [26]-[30].

Speech and language relearning require a long-term and intensive rehabilitation plan that involves different types of treatments and exercises. These interventions need many human and financial resources in hospitals and rehabilitation centres. The goal of Speech and Language Therapy (SLT) is to improve the patient's speech and language abilities [31]-[34]. There is some evidence that highly intensive, highly dosed, and long-term therapy have better results as compared

to low intensity, low dosed and short-term therapy [35]-[39]. The content of the SLT relates to the stroke patient's damage and intention, such as trying to get back to their speech before the stroke or withholding the current situation. One example of SLT is object identification, classified as simple or complex order comprehension. Simple order comprehension can be to "Put the glass close to the plate" and complex "Put the glass close to the plate and the glass close to a fork." However, the supply of required resources seems not to be enough for the drastically increasing number of stroke patients [40]. Therefore, alternative interventions for speech relearning exercises must be explored. Another critical issue with traditional speech interventions is compromised independent living. Generally, stroke survivors need to stay in the rehabilitation centre, and they are heavily dependent on medical caregivers to perform different kinds of exercises. Various studies suggested that living in the home environment has potential benefits for the patients' overall treatment; in fact, the process of rehabilitation and relearning seems to be more efficient and effective in their own homes [41]. In this context, the use of TES can play a vital role to perform speech relearning exercises at home.

Software applications to perform speech exercises may not only decrease the operational costs for medical caregivers, but it may also provide a sense of joyfulness and independence to the patient [42]. However, the acceptance of these applications depends heavily on the degree of trust in TES, eHealth literacy, ease of use of software applications, and patient's integrity. The software applications should be interactive, self-explanatory, and secure so that patients can quickly adopt and trust them [43].

Lack of tailor-made software applications for speech relearning exercises is also an essential factor to consider. Authors' previous studies highlighted that currently used speech relearning applications in rehabilitation centres are actually developed for school-going children rather than adults [4]-[15]. Stroke patients usually face difficulties using these applications, because of differences in context and learning behaviors between adults and children [4]-[16]. The intensity of speech deficiency differs from person to person where some patients may have some minor issues with communication. In contrast, others may not be able to speak even a few words [44]. Therefore, an individualized and tailor-made software application is needed so that it can be easily adapted according to the patients' current physical and mental condition. Stroke is most common in adults; however, commonly used speech relearning applications are not developed from an adult's learning perspective [45]-[47]. The adult learning theory highlights that adults actively participate in the planning, development, and implementation of their learning process [48]. Therefore, adult learning principles should be considered in the requirement identification process.

The study aimed to gather the requirements for designing an interactive speech relearning software application for stroke survivors. The requirements were also considered from the adult learning principles' perspective. The addressed research questions were:

1. What are the requirements for designing an interactive software application for speech relearning exercises following a stroke?
2. How can the principles of adult learning support understanding the patients' needs?

The remaining paper is organized as follows. Section II, addresses the Knowles' adult learning theory model, Andragogy in practice model is presented in Section III. Method is presented in Section IV, while findings and discussion are presented in Sections V and VI respectively. Finally, conclusion and future work are discussed in Section VII.

II. KNOWLES' ADULT LEARNING THEORY

Several studies have successfully used adult learning principles and andragogy (adult learning theory) in the practice model for education, training, and development of adult learners [13]-[19]. Andragogy highlights that adults tend to learn differently than the traditional children's education that is usually referred to as pedagogy [15]. Adults should be involved in the overall process of planning and implementation of learning objectives [20]. Knowles et al. described the following six characteristics of adult learning model that is guidance for them [15].

A. *Need to know*

Adults need to know the usefulness of learning objectives before they start learning. Adults invest considerable time and energy in exploring the perceived benefits of learning compared to the drawbacks of not learning. Therefore, the first task of the facilitator or instructor should be to bring the need to know to the learner's awareness.

B. *Self-concept*

Adults are usually self-directed, and they like to take responsibility for their decisions. A person tends to shift his or her self-concept from dependency towards self-direction. Adult learners' active participation and collaboration in the learning process is needed to enhance and stimulate their learning.

C. *Learning from experiences*

Adults are usually influenced by their past learning experiences, which vary from person to person. The facilitator/instructor should have a good understanding of an adult's previous experiences and beliefs in the given field. Knowles suggests an individualized learning plan for adults according to their previous experiences.

D. *Readiness to learn*

Knowles emphasizes the importance of task-oriented learning for the social and professional development of adults. The perceived social benefits of a learning task increase its readiness to support learning. The adults feel an urge to learn when they realize their changed circumstances and the role of learning in these situations.

E. Orientation to learning

Adults tend to learn the skills that have a direct impact on their real-life circumstances. Problem-solving tasks and exercises should be involved in the learning process. The focus of learning should be problem-centred rather than subject-centred.

F. Internal motivation

External motivation factors, such as a better job, good grades in education, and a higher salary are essential for learning. However, adult learning is heavily influenced by internal motivation factors, such as increased quality of life, satisfaction and pleasure at work, and self-esteem. Usually, adults are motivated for self-improvement and growth; however, this motivation is often compromised by a lack of resources, time, and violation of adult learning principles.

III. THE ANDRAGOGY IN PRACTICE MODEL

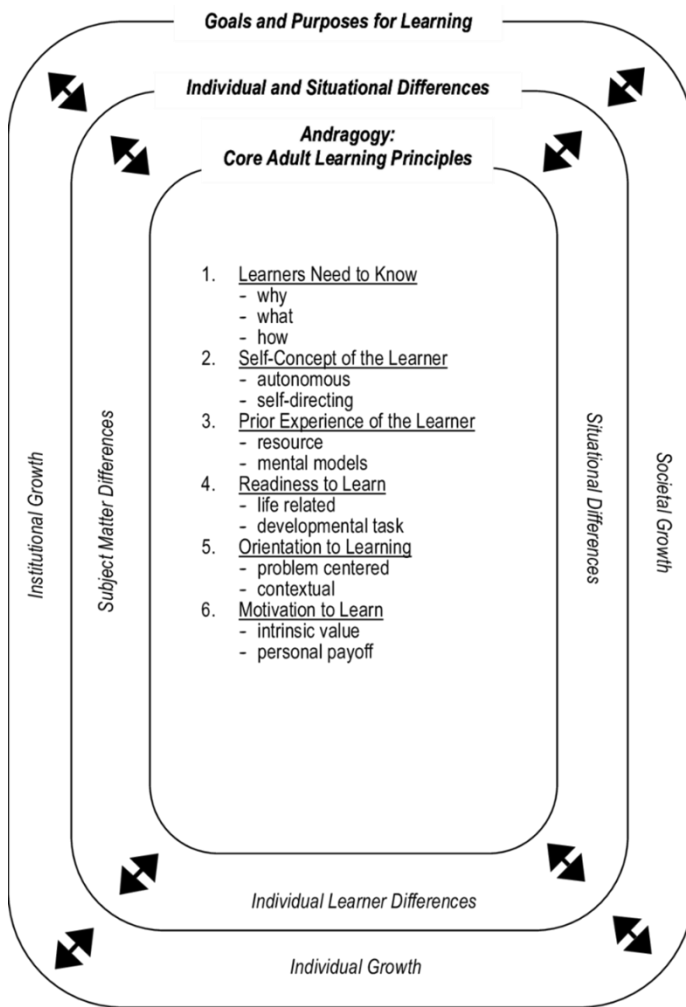


Figure 1. Andragogy in Practice Model [17].

Based on the adult learning principles as described in the previous section, Knowles suggested a conceptual

framework that can be adopted for several adult learning practices [15]. Since, most of the stroke patients are adults, adoption of the Andragogy in Practice Model (APM) is a promising approach for speech and language relearning as shown in Figure 1. As shown in the figure, the three dimensions of adult learning in practice may influence the adult learning process.

The outer ring presents goals and purposes for learning that can be seen as developmental outcomes for the learner. The goals can be categorized into individual, social and institutional growth of the learner. The middle ring shows individual and situational differences that might have an impact on learning practices. These differences are further categorized as individual learner differences, subject matter differences, and situational differences. The core six principles of adult learning were used as the primary themes that highlight patients' need for technology-enhanced speech and language relearning. The middle and outer rings of andragogy in practice model were used as filters; the core principles were examined through those filters to the requirements for the technology-enhancement following stroke.

IV. METHOD

The research methodology for this study is a design science research (DSR) that consists of a five-step process described by researchers in [24]. Generally, DSR consists of a rigorous process where a defined problem is solved by designing and implementing an artefact in order to make research contributions [21]-[23]. Since the study is about designing the requirements; a Requirement-Focused Design Science approach was adopted where the first two steps of the process were followed.

A. Data collection

Interviews are the most common approach for data collection and defining the requirements. Semi-structured interviews were conducted with some important stakeholders. The selection of participants is a tedious but essential part of the data collection process. The selection of highly competent and enthusiastic participants plays an essential role in the requirements specification [24]. A purposive sampling approach was adopted for the selection of participants, where all of the participants should have good knowledge and expertise in speech rehabilitation. Interviews were conducted with 11 participants; their professional role and experience in the related field are described below in Table 1. Participants 2-7 were interviewed several times for detailed information and requirements identification.

B. Data analysis

For data analysis, a deductive thematic analysis approach was adopted as suggested by [29]. Interviews, based on audio recordings and transcripts, were carefully explored for coding, and essential features of data that are directly relevant to speech and language relearning were established. The identified codes were examined according to the adult

learning theory described in the previous section, and the initial themes were gathered from data. The next step was to select and finalize essential themes. The initial themes were thoroughly reviewed, and the relevant themes that were important to answer the research question were selected. The most relevant and essential themes, such as independent living, tailor-made speech, and language relearning, and technology acceptance was analysed and presented according to Knowles adult learning principles.

TABLE I. STUDY PARTICIPANTS

Participants	Professional role	Years of experience
Participant 1	Speech therapist #1	25
Participant 2	Speech therapist #2	4
Participant 3	Speech therapist #3	5
Participant 4	Stroke specialist doctor and manger in the regional hospital	25
Participant 5	Occupational Therapist	5
Participant 6	Physiotherapist #1	8
Participant 7	Physiotherapist #2	3
Participant 8	Chairman of the local stroke patient organization	3
Participant 9	CEO of a small company working with game-based stroke rehabilitation	25
Participant 10	Hardware and software specialist at a big multinational company	9
Participant 11	Head of Stroke Team	15

C. Ethical considerations

Discussing physically and mentally impaired people has always been a sensitive issue when it comes to ethics. Ethical considerations are essential as a researcher, mainly dealing with people in the research and the consequences of the research on those people [26]-[29]. The Swedish Research Council [30]-[35] classified research ethics as professional ethics and categorized them in the following three subcategories: performing a fruitful work, following national and local rules and following the professional codes of ethics [36]-[39]. The third subset describes considerations regarding ethics for collaboration and working environment with co-workers.

At the start of every interview, the interviewees were briefed about the consent of correspondence, including some crucial

details about their right to withdraw some specific questions or entire interview at any point. Additionally, they were informed that the purpose of gathering information through interviews is only academic research. The confidentiality of the Participant is also an essential aspect of ethics [28]. The Participants were also briefed that their personal information, such as their names will not be mentioned in the research report. Moreover, the gathered data was safely stored at the university's database, where a strong password is needed for access.

Authors in suggested a close collaboration with the user groups [29]. In order to create a healthy work environment, the researcher should respect the user group, and the users should feel satisfied and secure. Therefore, semi-structured interviews were conducted in a warm environment. Medical caregivers, such as speech therapists were also interviewed for requirement specification. Before conducting the interviews, there were some open discussions between the speech therapists and the researchers to exchange knowledge in their area of expertise. These discussions will help the researchers to create a healthy and secure working environment. The article has been peer-reviewed and discussed at the 43rd Information systems research seminar in [33].

V. FINDINGS

The findings were analyzed thematically according to the Knowles Andragogy in Practice Model (APM); as shown in Figure 1. The patients' needs for technology enhancement are presented using adult learning principles as core themes. The adult learning theory and its principles were described to the speech therapist in regional rehabilitation (Participants 2). Supersizing, they have been considering speech and language from the adult learning aspects without knowing those principles, and they endorsed the idea of involving these principles for technology-enhanced speech and language relearning.

A. The patient's need to know

Several informants describe the necessity to involve the patients from the beginning while discussing relearning (Participants 1- 4, 11). They all emphasize the importance of describing the actual situation and what they can achieve. Informant 4 describes this question as to the most common second question from the patients, where the first one is if they are going to survive or not. By setting the goals, the patients can understand what they possibly can achieve by training. The actual situation is described as what happens if the patients skip their training.

The bases for the patient's learning objectives are several. One is the goals and another the patient's motivation for relearning. Highlighted is also the patient's physical condition, which is assessed at a specific meeting with a speech therapist (Participants 1-2). The assessment is conducted as a standardized procedure, involving sets of detailed assignments. Before starting the standardized procedure, the speech therapists decide which parts to assess, based on the patient's described injuries. The assessment relies on an

analogue procedure, developed and used in Sweden by speech therapists, and is commonly used throughout the country. Both speech therapists are keen on converting the analogue assessment process into a digital one, where the results would easily be stored and used as input for the relearning assignments.

B. Self-concept of patients

Since adults are usually self-directed, they would like to take responsibility for getting the information about their disabilities and the process of recovery. Several participants highlighted that patients like to get information from their relatives and friends (Participant 2, 5-7). Therefore, the patient's close relatives and friends can play an essential role in the success of a technology-enhanced system. One speech therapist mentioned ongoing research involving the close relatives of patients in the speech relearning process (Participant 2). That research focuses on educating and training the patient's relatives so that they will be able to help patients to perform relearning exercises. The software should have a feature that enables the patient's relatives to collaborate with the patient as well as the speech therapist (Participant 2). An online session with the speech therapist, the patient, and the patient's close relatives such as the husband or wife of the patient can be helpful not only for the patient to perform a different kind of speech relearning exercises but for the speech therapist as well to guide the patient for those exercises.

Personal integrity is also a matter of concern for the stroke survivors while performing therapy from a distance. People do not like to be monitored all the time during the rehabilitation exercises; they want to do the exercises independently as much as possible (Participant 5-7). The patients should be able to use the application independently with the least interaction or guidance from the therapist (Participant 2, 3).

C. Adult patients learn from their experiences

Adults learn from their previous experiences, such as knowledge from previous understandings about TES build a perception of the use of TES. It is, therefore, essential to consider patients' previous practices and knowledge about technology enhancement. Many of the available software for speech is developed for English speakers; however, the speech therapies should be conducted in the native (Swedish) language (Participant 2, 11). The Head of the local mobile stroke team highlighted that the number of immigrants with different languages is increasing in Sweden and healthcare givers need more and more resources for translation services. Therefore, the option of selecting different languages in the software is preferable (Participant 11).

To use speech relearning exercises, education and training are also needed not only for the patients but for the speech therapists as well (Participant 2). Medical staff faced many difficulties in setting up online meetings with medical caregivers; therefore, it might be more challenging for them to guide the patients who are already facing impairments because of stroke (Participant 2, 3). Older people particularly face more problems while using speech relearning exercises on smartphones and tablets (Participant 1). Older adults with

limited previous experience of using TES have more difficulties than the younger generation and disability after a stroke makes it even more challenging for them (Participant 1, 4-7).

D. Readiness to learn

After designing the learning strategy and tools, the patients should be prepared for the implementation of the learning strategy. Proper education and training, usability considerations, and social aspects of TES might increase the readiness to learn for patients. Almost all the participants emphasized the importance of technology acceptance requirements such as usefulness, ease of use, adaptability, and satisfaction of the software application (Participants 1-8, 11). Two of the speech therapists informed us that there are some applications available for speech relearning exercises; however, they have not developed specificity according to stroke patient's medical conditions (Participant 1, 2). The tendency to use those applications heavily depends on the degree of impairments after stroke and the overall patient's health (Participant 5-7).

Two speech therapists suggested different levels of login settings for patients and medical caregivers. The software should have a simpler version of the interface for the patients where they can perform their exercises; however, the speech therapists should have a detailed version where they can administer, and suggest and monitor different kinds of speech therapies (Participant 2, 3). The stroke specialist doctor highlighted that the patient should feel a sense of pleasure and satisfaction while using software applications; therefore, goal-oriented training with the element of entertainment can improve the usability of this software (Participant 4). One suggestion, from the chairman of the local stroke organization, is the involvement of music and dance during the relearning exercises (Participant 8).

E. Orientation to learning

The relearning strategy should be individual-focused rather than disability-focused. Therefore, an individualized learning plan is needed for patients with different medical, social, and professional background. Participants with medical backgrounds highlighted that the technical requirements could differ according to the patient's medical condition and their perception about the use of technology enhancement (Participant 1-7). Patients with impaired cognition might have problems using complex text-based interfaces. Therefore, applications with features of recording and replaying can be beneficial for those types of patients, especially for pronunciation training (Participant 1). Patients with severely impaired language skills are recommended to use image-based tools, such as photographs, for communication (Participant 1, 2).

Due to the brain injuries after stroke, the patient's focus for doing different tasks is also decreased. Therefore, exercises with low intensity and a shorter period are more beneficial than high-intensity exercises (Participant 1, 5). In some cases, a patient's vision is blurred after stroke, and they can have a limited view of things; however, the interfaces are mostly designed for the users with full vision (Participant 1, 2).

Therefore, the interface should be designed according to the patient's view level. With severe physical condition, eye-tracking technology might be helpful where patients can navigate the interface through eye movement (Participant 10).

A stroke survivor's choice of hardware also depends upon his physical condition; the software should be usable on different types of devices such as smartphones, tablets, and computers (Participant 1-3). The same requirement is suggested by the hardware and software expert, the application should be platform-independent, and it should be compatible with different kinds of hardware (Participant 10).

F. Internal Motivation of patients to relearn

Participants 1 - 4 emphasized that internal motivation is essential while discussing what can be achieved. For a person involved in managing various situations, such as being a politician or chairman, is the speech of specific interest to continue activities conducted before the stroke as much as possible. Therefore, the patients need to know what they can do to live their lives as much as possible as before the stroke.

Living independently in the home environment has some potential benefits for stroke survivors as it increases their internal motivations for relearning. The mobile stroke team highlighted that most of the patients want to go home as soon as possible and feel secure in the home setup (Participant 5-7). The relearning process is fast in the home environment where patients can get help and inspiration from their loved ones (Participant 2).

VI. DISCUSSION

The primary aim of this paper was to gather the requirements for the development of an interactive speech and language relearning software for stroke survivors. Some essential requirements were gathered with the help of different stakeholders involved in stroke rehabilitation. Especially speech and language therapists (Participant 1-3) played an important role by describing the patients' needs according to their impaired medical condition. The secondary aim of this research was to analyze the requirements of Knowles's adult learning theory perspective. Some other related studies also highlighted the involvement of adult learning principles in the speech and language relearning process might increase the efficiency and effectiveness of relearning for stroke patients [31][32]. Andragogy in Practice Model [15] was used as a theoretical framework for speech, and language relearning was developed. In the following discussion, the main findings from empirical data are discussed from previous literature in the field and adult learning principles viewpoint.

Most of the participants highlighted that the requirements are different for different patients according to their physical and cognitive abilities. Several previous studies on speech and language rehabilitation also highlighted the same factor [6][33][34]. Researchers in [44-45] argued that the intensity of relearning exercises should be according to the patient's focus or concentration level; less intensive and short exercises showed better improvement for the patients with low focus levels⁶. Authors in [46-48] also highlighted that the individual differences of an adult play an essential role in adult learning, and an individualized learning plan is needed [15]. Therefore,

the speech therapist should be able to make an individualized relearning plan for the patients according to their medical condition. The speech therapist should have extra functionalities in software so that they can adjust the relearning exercises according to the patient's needs.

Speech therapists suggest a patient-centered approach; both patients and therapists should be involved in the process of software development. As highlighted by [17], adult learners should be involved in the planning and implementation of their learning objectives. Adults want to understand the learning goals before they start learning and their involvement in defining, planning and implementation of the learning process may increase the effectiveness of learning. The importance of user-central design is already a well-known factor from the literature [5][33]; however, very few studies are conducted where both patients and the therapists are involved in the software design process [4][35]. The requirements should, therefore, be looked at from the user's point of view.

Several participants showed some significant concerns about the usability of software applications. Medical caregivers highlighted that they faced many problems using Technology-Enhanced Systems (TES) such as connectivity errors, audio and video efficiency, and screen sharing issues with an online meeting. Proper education and training of the given software is always an essential aspect of usability [36]. Education and training are not only crucial for patients but the speech therapist as well. Usually, speech therapists recommend and educate patients about the use of rehabilitation applications; therefore, therapists need to get familiar with that application first. From the adult learning viewpoint, education and assistance about learning strategies and tools might increase the readiness to learn; the patients should be prepared for the implementation and use of selected tools and technologies for speech and language relearning.

Another important aspect highlighted by the participants is the involvement of patients' relatives and friends in the relearning process. Patients with impaired physical and mental conditions feel more comfortable, secure, and motivated if their loved ones can be involved in the relearning process [13][18][37]. Usability and usefulness can also be improved by adding social networking features in the application where patients may connect with patients, share their stories and experience, and play online games with each other [38]. The social aspects of learning are also crucial for adult learners, as discussed in [42-43], they argued that the social benefits of a learning task increase its readiness to learn.

Software applications to perform speech exercises may not only decrease the operational costs for medical caregivers, but it may also provide a sense of joyfulness and independence to the patient [2][39-42]. However, the acceptance of these applications depends heavily on the degree of trust in TES, eHealth literacy, ease of use of software applications, and patient's integrity [43-45]. The software applications should be interactive, self-explanatory, and secure so that patients can quickly adopt and trust them [46-48].

VII. CONCLUSION AND FUTURE WORK

With the help of some experienced and enthusiastic participants, some essential requirements for technology-enhanced speech and language relearning were gathered. Since stroke is most common in adults and adults learn differently than children, adult learning theory was helpful to understand the patients' needs. Adult patients like to involve in the development of their relearning process. Therefore, a speech and language assessment software should be the first step in technology enhancement where a speech therapist can show the patients the level of their current and/or previous impairments and plan a future strategy for their relearning.

The relearning process should be decided according to patients' internal and external circumstances such as the general medical condition of the patient, intensity of speech and language impairments, and patient's social and professional life. Therefore, speech therapists need extra management functionality in the relearning software so that they can adjust the exercises according to the patient's needs.

This study found essential requirements for the future development of technology-enhanced applications for speech and language relearning tailored for stroke patients. The next planned steps are to design, develop, and evaluate two technology-enhanced applications to support the diagnosis and the relearning process after stroke. Both these applications should be designed and tested with a multi-stakeholder approach involving caregivers, software developers, stroke patients, and stroke patients' friends and family. To carry out the work with a multi-stakeholder approach is essential since a stroke patient's speech relearning journey back to an independent life is a long and tedious one.

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Factors Influencing Acceptance of Technology-enhanced Speech and Language Relearning for Stroke Survivors – A Systematic Review

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Speech and language loss is the most common disease for stroke survivors. The process of relearning communication skills is difficult and a time taking process. Technology-enhanced systems (TES) can be useful in speech and language relearning, however, the acceptance and usability of TES for stroke patients have been a matter of concern and more research is needed in this area. This study is therefore aimed to explore the factors that might influence the acceptance of technology-enhanced speech and language relearning after stroke. A systematic literature review was conducted to determine the technology acceptance factors. To ensure the state of the art in the given field, 97 articles written from 2016 to April 2021 were retrieved with a search string aligned to the research question. After applying the exclusion criteria and quality assurance, 13 articles were selected for inclusion. An overview of selected articles, their chosen methodology, and main findings from the articles was presented in a pre-defined table. The results show that patients' physical and cognitive condition, the intensity of relearning exercises, native language, the involvement of friends and family, technical assistance and training, selection of hardware and usability of the graphical interface are important factors for acceptance of TES. Stroke patients tend to use TES. Independent living, treatment in the home environment, and improved quality of life are the major motivations for use of TES. However, TES should be tailor-made and a user-centre approach should be adopted. Finally, proper education and training are essential not only for the patients but for the speech therapists and patients' relatives and friends as well.

CCS CONCEPTS • Human-centered computing • Interaction design • Empirical studies in interaction design

Additional Keywords and Phrases: Stroke Rehabilitation, Speech and Language relearning, E-Health, Independent Living, Tailor-made Software

1 INTRODUCTION

The presence of speech and language impairments is common among stroke patients and almost one-third of the stroke survivors suffer from communication problems [1, 2]. After stroke, patients' ability to speak, listen, read, and write is decreased to different degrees, which create major hinders in their daily life communication [1]. Consequently, the quality of a patient's social and professional life is heavily affected [3]. Due to other post-

stroke issues such as physical and cognitive injuries, the patients feel isolated and depressed. In order to overcome these post-stroke problems, the speech and language relearning process is recommended to start as soon as possible after stroke [1, 4].

Different types of therapies are prescribed by speech therapists for communication improvement. These therapies showed great improvements in communication [1], however, the required financial and human resources for these treatments are very high and sometimes insufficient at the rehabilitation centres [3]. Some cost-effective and innovative interventions are needed for these devastating communication deficiencies.

Several studies highlighted the benefits of involving Technology-enhanced systems (TES) in speech and language relearning [5-7]. However, the acceptance and usability of TES is a matter of concern. Even though a number of sophisticated applications are developed during the last two decades [8-10], the adoption of these technologies for stroke patients is still a challenge [3, 11]. More research is needed to find the technology acceptance factors for speech and language rehabilitation following a stroke.

1.1 Aim

The study aimed to investigate and discuss the important factors that could influence the acceptance and use of interactive software applications to support speech and language relearning for after stroke patients.

The research question addressed was:

What are the critical factors for the acceptance of interactive software applications to support language relearning after stroke?

The determinant factors are expected to play an important role in defining the requirements of speech relearning software for stroke survivors.

2 METHOD

This study was carried out as a systematic literature review according to the five-step model described by Parahoo (2014), and Cronin et al., (2008) [12, 13]. The first step was to select a topic and to formulate a research question, followed up in the second step by the definition of search keywords, inclusion criteria, and exclusion criteria. In the third step, the defined search keywords were combined in a search string for searching and retrieving a relevant set of articles. The following fourth step consisted of a relevance assessment of the retrieved articles based on the inclusion criteria described here below. Finally, the fifth and the last step involved the important analyse and synthesise of the selected literature before the presentation of the results.

The four inclusion criteria that were defined in step 2 consists of: 1) Only to build on peer-reviewed research articles in the English language, and 2) To accept studies using quantitative, qualitative as well as mixed research methodology for a holistic view of the chosen topic, and 3) Selected articles should build on research that has genuine focus on information technology for speech relearning, and 4) Relevant research articles should have a research focus on technology acceptance or usability regarding digital systems for speech relearning.

According to the chosen methodology exclusion criteria should also be created in step 2, which for this study were defined to exclude: 1) Duplicates, and 2) Non-research articles such as newspaper articles, white papers, tutorials or workshop summaries, and 3) Articles older than 2016 to strive for state-of-the-art research, and 4) Research with a focus on more general stroke rehabilitation and not specifically speech and language relearning

after stroke, and 5) Studies on aphasia from other aspects than the aphasia caused by stroke, and finally 6) Articles that could not be fully accessed.

The search string used to retrieve relevant literature was:

("stroke patients" OR "stroke survivors") AND ("language" OR "aphasia") AND ("relearning" OR "rehabilitation") AND ("eHealth" OR "information technology") AND ("tailor-made" OR "target group" OR "Custom-made" OR "customised")

3 RESULTS

With the above-described search string, a total of 97 articles were acquired from Google Scholar. After applying the inclusion and exclusion criteria and reading the abstracts, 24 most relevant articles were selected for further investigation. To ensure the quality and relevance of the select literature, only journal articles, and some well-cited conference papers were chosen. Furthermore, articles that don't contain a well-documented research methodology were also excluded. 11 articles were selected after the quality and relevance assessment and two more articles were added by using the backward search technique. In a backward search, the references of selected are also explored to get some more relevant results as described by Vom Brocke et al [14].

In table 1 below, the selected articles are presented in ascending order of publication year. The first column describes the author's name, year, title, and country of the conducted study. The second column describes the methodology of the study and the number of involved patients and/or medical caregivers. The third column describes the main findings of studies and important factors that might influence the acceptance and use of TES for speech and language relearning.

Table 1: Selected articles and main findings

Author(s), Year, Title, Country	Method, Participants	Findings and Critical factors
Simic, Tijana, et al. (2016). "A usability study of internet-based therapy for naming deficits in aphasia." <i>American Journal of Speech-Language Pathology</i> [15], Canada	Usability testing using System Usability Scale (Brooke, 1986), Patients: 6 Clinicians: 2	Aphasia patients tend to use Internet-based speech and language therapy, however, the medical caregivers' perspective may play an important role in the usefulness of TES. Highlighted critical factors are user satisfaction, patient-clinician interaction, and patients' ability to TES.
Kesav, Praveen, et al. (2017). "Effectiveness of speech language therapy either alone or with add-on computer-based language therapy software (Malayalam version) for early post stroke aphasia: A feasibility study." <i>Journal of the neurological sciences</i> [4],	Quantitative Study Statistical analysis Patients: 24	The use of computer-based therapy depends upon the medical condition of the patient and the intensity of therapies. Less intensive exercises showed more improvement than highly intensive exercises. Effectiveness and acceptance of TES are better when the software is in the native language.

India		
Roper, Abi, et al. 2018. "Usability Testing-An Aphasia Perspective." <i>Proceedings of the 20th International ACM SIGACCESS Conference on Computers and Accessibility</i> [16],	Qualitative Study based on semi-structured interviews	Digital technology acceptance for varying patient's physical and cognitive abilities heavily depends on their participation in the process of designing the TES. The usability of software can be increased by involving patients in the development process. Therefore, a user-centred design approach should be adopted.
United Kingdom		
Tousignant, Michel, et al. (2018). "Satisfaction with in-home speech telerehabilitation in post-stroke aphasia: an exploratory analysis." <i>Journal of the International Society for Telemedicine and eHealth</i> [1],	Quantitative Study based on surveys Participants: 20	Motivational factors for the use of telerehabilitation are independent living and treatment in the home environment. The involvement of friends and family may increase satisfaction by conducting therapy in the home environment.
Canada		
Øra, Hege Prag, et al. (2018). "Telerehabilitation for aphasia–protocol of a pragmatic, exploratory, pilot randomized controlled trial." <i>Trials</i> 19, 208 [17]	Randomized controlled trial (RCT), questionnaires and semi-structured interviews Patients: 80	The intensity of therapy has a major impact on the success of telerehabilitation for aphasia. Exercises with low intensity are more feasible for telerehabilitation. The TES should be tailor-made according to the patient's language deficiency and focus level.
Norway		
Garcia, Manuel B. (2019). "A Speech Therapy Game Application for Aphasia Patient Neurorehabilitation–A Pilot Study of an mHealth App." <i>International Journal of Simulation: Systems, Science & Technology</i> [18]	Usability testing using System Usability Scale (SUS) Patients: 5 Speech therapists: 2	Usefulness can be improved by adding a social networking feature where patients can connect and play games. Online rehabilitation can be more useable if different stakeholders (friends, family, and therapists) can collaborate and help the patient. Tablets or desktop computers are more suitable for older adults and people with impaired eyesight after stroke.
Philippines		
Marshall, Jane, et al. (2019) "Technology-enhanced writing therapy for people with aphasia: results of a quasi-randomized waitlist controlled study." <i>International journal of language & communication disorders</i> [19]	Quasi-randomized wait-list controlled design Patients: 21	Assistive technologies such as speech to text conversion software can be helpful to relearn the writing skills, however, the interface is interactive and easy to use. The patients need education and training to learn and use these assistive technologies.
United Kingdom		

<p>Ahmad, et al. (2019) “Testbed requirements for technology-enhanced stroke rehabilitation to support independent living” (<i>INSTICC Press, 2019.</i>)[3],</p> <p>Sweden</p>	<p>Design science</p> <p>Medical caregivers: 5</p>	<p>Independent living and improved quality of life are one of the biggest motives for the use of TES. Human-computer interaction factors such as privacy, trust, and user-friendliness need to be considered in order to improve acceptance of technology.</p>
<p>Ahlin, et al. (2019) "Determining Testbed Requirements for Technology Enhanced Speech Rehabilitation after Stroke-the Informed Co-workers' View Point." <i>IARIA GLOBAL HEALTH International Conference on Global Health Challenges</i>[7]</p> <p>Sweden</p>	<p>Design science</p> <p>Participants: 10 Speech therapists: 2</p>	<p>TES for speech and language relearning should be based on different goal-oriented exercises, joyful and tailor-made. A patient's close relatives and friends can provide good help and motivation for the use of TES.</p>
<p>Mallet, Karen, et al. (2019) "RecoverNow: A patient perspective on the delivery of mobile tablet-based stroke rehabilitation in the acute care setting." <i>International Journal of Stroke.</i>[20]</p> <p>Canada</p>	<p>A quantitative study, open text response engagement survey</p> <p>Patients: 30</p>	<p>Stroke patients tend to use mobile tablet-based for relearning communication skills, however, technical assistance and education to use TES are needed.</p>
<p>Lavoie, et al. (2019) "Efficacy of a self-administered treatment using a smart tablet to improve functional vocabulary in post-stroke aphasia: a case-series study." <i>International journal of language & communication disorders</i> [21]</p> <p>Canada</p>	<p>Multiple baseline single-case series using ABA design</p> <p>Patients: 4</p>	<p>The potential of smart tablets are good for naming improvement; however, the exercises need to be done under the supervision of skilled speech therapists. Technology-enhanced therapies for vocabulary have significant improvements in communication that have some good impacts on the quality of life of aphasia patients</p>
<p>Wu, D. (2020). Use of an Internet-of-Things Smart Home System for Healthy Aging in Older Adults in Residential Settings: Pilot Feasibility Study. <i>JMIR aging</i>, 3(2), e21964 [22]</p>	<p>Feasibility study</p> <p>Participants: 37</p>	<p>The use of Internet of- Medical Things (IoMT) devices are helpful for elderly patients to achieve independent living and better quality of life. Smart home technologies such as smart speakers, windows and door sensors, and humidity and temperature sensors were mostly endorsed by the patients, however, people were reluctant to use IP cameras due to the perceived privacy concerns.</p>
<p>Vaezipour, et al., (2021). “It’s really exciting to think where it could go”: a mixed-method investigation</p>	<p>Semi-structured interviews and survey</p>	<p>Virtual reality(VR) based applications showed promising benefits for speech therapists as well for stroke patients. The effectiveness and usability of</p>

of clinician acceptance, barriers and enablers of virtual reality technology in communication rehabilitation. Disability and Rehabilitation [23]	Participants: 15	these systems can be improved by providing proper training and education about VR applications. The improved infrastructure and equipment to integrate and adopt the VR systems are also important factors to consider. Lack of awareness and fear to use technology were also highlighted as potential barriers for technology acceptance.
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4 DISCUSSION

This study aimed to determine the main factors that could play a crucial role in the acceptance of speech and language relearning software. To explore these factors, It is important to understand the post-stroke impairments [24]. For example, stroke patients' focus level is decreased to different degrees and they get tired after performing small tasks, therefore, less intensive exercises are more suitable than highly intensive exercises [4]. The software application should, therefore, contain tasks and exercises that are short and easy to perform.

Decreased eyesight is another post-stroke impairment; many stroke patients have limited vision and they need a bigger screen size to watch [3]. Therefore, it is suggested to use tablets or desktop computers instead of smartphones for those patients [18]. Due to impaired cognition, stroke patients struggle to learn and use complex and difficult interfaces [7, 15], therefore, the background of the interface should be as simple as possible, font size should be bigger than usual and colours should be more contrastive between selected and unselected items on the screen [15, 18].

Patients' close friends and relatives may help them during an online therapy session [1, 7, 18]. A feature in the software application that provides the involvement of friends and family may enhance a better user experience [18]. Another important and well-known aspect of learning and relearning is that the software should be in the native language; several studies highlighted the importance of the native language of software [4, 7, 18].

Most of the studies showed that the use of technology in speech and language relearning seems beneficial for stroke survivors, and they experience an improved and independent life with the use of technology. The acceptance of technology, however, is doubtful for stroke patients of some critical factors such as privacy, personal integrity and trust in technology. The involvement of medical caregivers and stroke patients in the interface design process is also a key factor for better acceptance and usability [7, 15, 16, 24]. Technical assistance and training of TES is important for patients, their relatives, speech therapists, and others that might help out during the rehabilitation process.

4.1 Relation to similar studies:

Several literature studies have been conducted previously to explore general technology acceptance factors in different areas of life [11, 25-29]. However, literature reviews on technology acceptance for speech and language relearning are scarce. Most of the studies have not considered the technology acceptance for patients with different types of disabilities. To our knowledge, this the first literature study to find the critical factors for acceptance of speech and language relearning with the help of an interactive software application. X Zhou et al. argued in his study that the use of mobile applications is effective for speech rehabilitation after stroke [10], however, some other studies highlighted that the patient's eyesight is affected after stroke [7, 18]; hardware

with a bigger screen such as laptop or tablet is more efficient for the stroke patients with an impaired vision[18]. Our study has, therefore, a broader scope where different kinds of hardware and software are considered. Many studies focused on the acceptance of ICT among older adults [11, 25, 27, 30]. Since stroke is most common in elderly people [3], some of our findings are similar to studies conducted for older adults.

4.2 Limitations of this review and suggestion for future review.

The study had some limitations to be acknowledged. One limitation of the study might be that the selected articles are not representing all the potential users of TES for speech and language relearning. There were a few articles involving all stakeholders for speech and language relearning. The involvement of medical caregivers is important to determine the TES acceptance factors [3], however, many of the selected articles did not include the medical caregivers in the studies. This limitation indicates that more research is needed where medical caregivers such as speech therapists' viewpoints are also considered.

Moreover, the participants of the selected studies were not analyzed by considering their age, gender, and their previous experience of using TES. These characteristics of users are also important to consider, for example, some technology acceptance factors are not as important for younger people as they are for older adults [11]. A more detailed review is therefore needed where the different characteristics of users are considered. Our exclusion criteria might also influence the results; the articles that were not written in English and that were not online available might contain some important findings that could not be included in the study.

5 CONCLUSION

Despite their impaired medical condition, stroke patients tend to use TES for speech and language relearning. The study findings indicate that independent living, treatment in the home environment, and improved quality of life are the major motivational factors for the use of TES. However, the usability factors of software and hardware such as customized graphical user interface and bigger size of hardware screen are vital for the acceptance of TES. Proper education of technical and medical aspects of the software are also important for higher user acceptance.

6 FUTURE WORK

The study identified some critical factors that could influence the use and acceptance of technology-enhanced speech and language relearning for stroke survivors. The next natural step would be to define the requirements based on the identified critical factors. The requirements should be defined for the development of a software application for speech relearning following stroke where the identified critical factors could play an important role.

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

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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:

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.

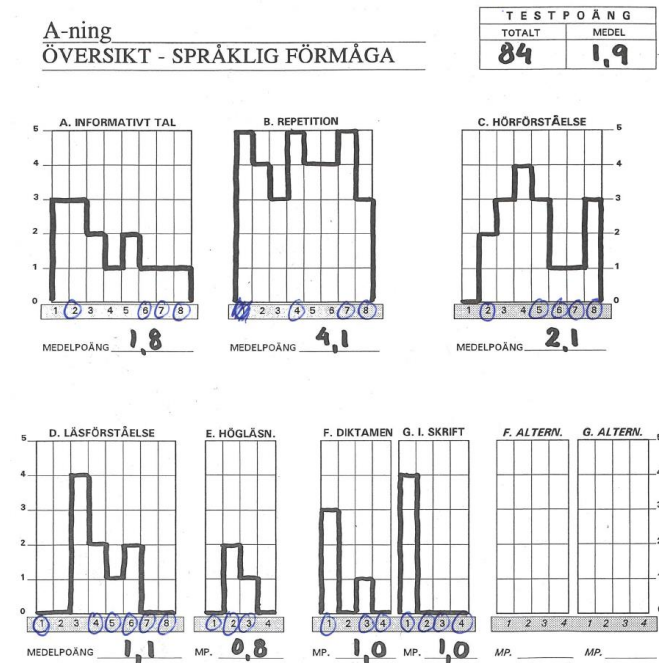


Figure 2. Manual and paper-pen based evaluation

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.

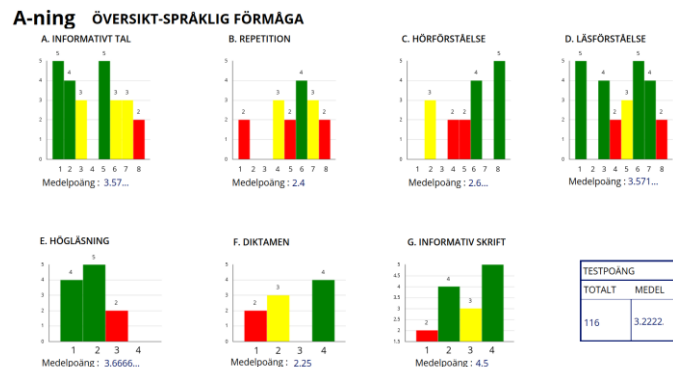


Figure 3. Digital Speech and language Evaluation System

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 (2014) 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].

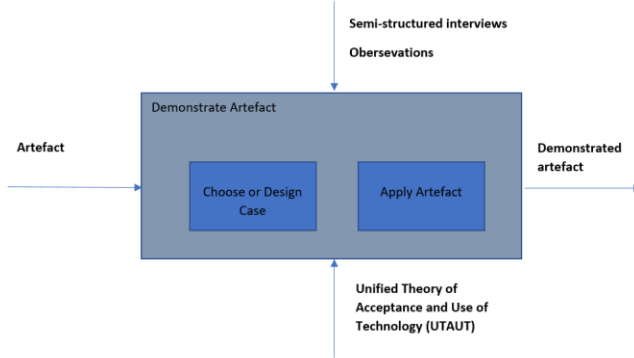


Figure 4. Demonstrate artefacts Activity

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 (2014), 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.

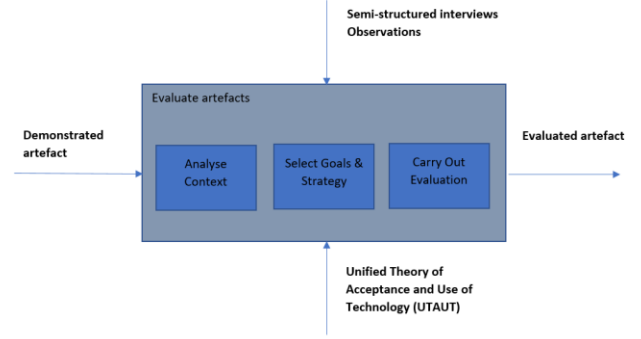


Figure 5. Evaluate artefacts Activity

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].

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 statistics 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