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Exploring the Role of AI and Technology in Language Therapy: A Case Study on Pronunciation Training and Real-Time Feedback in Rhotic Therapy

A Dissertation Submitted to the Department of English in Partial Fulfillment of the Requirements for the Degree of Master in Linguistics

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Dedications

I dedicate this work to my beloved family ...

To my mother, father, and brothers, for their endless love, support, and guidance.

Thank you for standing by me throughout my journey.

To my partner Hadil and my dear friends, for bringing light and encouragement along the way.

And to myself, for staying strong when the path was hard.

With heartfelt gratitude

Wafa

My dedication to my wonderful parents for their sacrifices, guidance, their endless love, and beliefs in me.

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To my soulmate for supporting me and being with me in every moment.
To myself for being strong in the hard moments.

With heartfelt gratitude

Hadil

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To all who walked beside us with kindness and grace

our deepest, eternal thanks.

Abstract

This study investigates the impact of technologies, particularly Artificial Intelligence (AI) and digital tools, in the field of language therapy. It compares the effectiveness and engagement of contemporary technology-mediated practices with traditional therapeutic approaches. The research explores the activities, impact, and accessibility of various technology-powered speech therapy applications, telepractice, and interactive digital interventions in relation to face-to-face therapy sessions. Employing a mixed-methods approach, the study includes observations, questionnaires, and a case study involving language therapists, doctors, parents, and learners. The questionnaire, completed by 95 participants, assesses perceived benefits, drawbacks, and implementation challenges of both technology-mediated and traditional interventions. Additionally, the case study evaluates the role of AI in enhancing speech therapy. Ethical considerations, such as data usage, privacy, consent, and accessibility, were also addressed. The findings indicate a growing interest among practitioners in utilizing AI and remote tools for speech therapy, particularly in remote and underserved areas where access to traditional therapy is limited. Overall, this study provides both practical and theoretical contributions to the understanding of AI integration in speech and language therapy, offering implications for future research, clinical practice, and policy development in the domain of digital health and communication disorders.

Keywords:

Artificial Intelligence (AI), language therapy, digital tools, speech therapy, telepractice, traditional therapy, technology-mediated interventions, case study, ethical considerations, clinical practice.

Table of Content

Chapter Three

Methodology, Data Analysis and Interpretation

List of Tables

List of Figures

List of Abbreviations & Acronyms

DLD: Developmental Language Disorders

SLP: Speech Language Pathologist

ALS: Amyotrophic Lateral Sclerosis

ASHA: American Speech-Language-Hearing Association

VMI: Visual Motor Integration

APD: Auditory Processing Disorder

AI: Artificial intelligence

ASR: Automatic Speech Recognition

TTS: Text-to-Speech

NLP: Natural Language Processing

ML: Machine Learning

AAC: Augmentative and Alternative Communication

SLP: Speech-Language Pathologist

SLI: Specific Language Impairment

ASD: Autism Spectrum Disorder

HIPAA: Health Insurance Portability and Accountability Act

CLA: Computational Language Assessment

VR: Virtual Reality

RSSD: Residual Speech Sound Disorder

KR: Knowledge of Results

KP: Knowledge of Performance

General Introduction

General Introduction

Language therapy plays an essential role in assisting patients with speech and communication disorders. These disorders pass from difficulties in understanding and making speech to language-based learning disabilities like dyslexia and auditory processing disorders. Tradition language therapy has been managed through in-person sessions led by speech-language pathologists (SLPs), focusing on structured interventions tailored to patient needs. This goes into traditional approaches to language therapy, such as Van Riper's method, phonetic placement techniques, (Messner et al., 2020). Although, with rapid advancements in technology, digital tools such as teletherapy, artificial intelligence (AI), assisted speech programs, and mobile applications have emerged as cover approaches to traditional therapy methods (World Health Organization [WHO], 2018). . These innovations have opened new possibilities for both clinicians and patients; however, they also come with limitations. Ranging from technical barriers to ethical concerns as data privacy and AI bias.

In spite of the growing adoption of technology in healthcare, concerns carry on regarding its effectiveness compared to conventional therapy. While some researchs show up the benefits of increased accessibility and real-time feedback, there are others argue that digital interventions want the human interaction necessary for personalized treatment adaptation (Walsh & Tunkel, 2017).

By examining both approaches, this work lines up to show up the value of integrating evidence-based therapeutic practices with emerging technologies to create more effective, and useful language therapy strategies.

1. The Research Problem

While language therapy methods have given an idea of strong effectiveness in managing a large range of speech and language disability, they present challenges related to availability, treatment, and patient engagement. At the same time, turning up technological innovations and advancements in artificial intelligence have led to the development of advanced tools that offer promising support and enhancements to traditional therapeutic practices (Fairweather et al., 2020). Nonetheless, the widespread acquisition of these digital solutions in professional positions remains questions regarding their sustained usefulness, ethical considerations, and adjustment with established clinical methods continue to stand up. This research aims to examine the impact of technology-based interventions such as AI-enabled applications and remote therapy platforms comparing with the traditional speech-language therapy in terms of therapeutic efficiency, accessibility, and patient satisfaction. Furthermore, the study will investigate the benefits of a blended approach that integrates digital innovations with time-tested therapeutic frameworks to optimize treatment outcomes for patients affected by language disorders (Desjardins, 2022; Grogan-Johnson et al., 2021).

2. The objective of the Study:

The overall aim of the study is:

- To compare the success of traditional language therapy methods versus technology driven interventions.
- To propose strategies for integrating modern technologies with traditional therapy in language therapy.
- To investigate the impact of digital technologies and artificial intelligence on the quality of speech language therapy.
- To identify the challenges and limitations associated with both traditional and technology-based language therapy, and the absence of communication signs.

3. The Research Questions:

The current research aims to address the following research questions.

1. What are benefits the technology-based language therapy interpositions compared to traditional face-to-face therapy methods in treating speech and language disorders?

2. Does the use of AI-powered and digital therapy tools increase accessibility and personalization of speech and language therapy for patients in remote or underserved areas?

3. What are the main differences in engagement and satisfaction between the pathologists who use traditional therapy and those using technology-assisted language therapy?

4. What are the ethical and practical challenges associated with AI tools in language therapy, and how do they affect therapists' and patients' preparedness to adopt these technologies?

4. Research Hypotheses:

So as to answer the research question, hypothesize that:

1. Technology-based interventions are fairly or more successful than traditional face-to-face therapy in improving speech and language outcomes, particularly in structured and repetitive tasks.

2. AI-powered and digital therapy tools crucially improve access to and customization of language therapy services for patients in remote or underserved regions compared to traditional methods.

3. Users of technology-assisted language therapy announce higher levels of engagement and satisfaction because of interactive features and real-time feedback, compared to users of traditional therapy alone.

4. Treats related to data privacy, cost, and the perceived lack of human empathy in AI tools negatively impact the willingness of both therapists and patients to fully adopt technology-based language therapy solutions.

5. Significance of the Study:

This significance of studying the advancements in digital tools and artificial intelligence in speech language therapy, it examines both traditional and technology-driven methods of speech language pathology. By comparing digital and traditional therapy approaches, this research may inform doctors, educators, and policymakers about the most effective strategies for language rehabilitation. Additionally, it gives to the broader discourse on the future of digital healthcare interventions, highlighting best practices for integrating technology into therapeutic contexts.

6. The Methodology:

To gain a comprehensive understanding of the challenges, benefits, and good results in the treatment of language disorders through both traditional and technology-assisted therapy, mixed methods approach was affected in this study. Three data collection tools were used to collect both qualitative and quantitative data, offering a broad and balanced view of present-day therapeutic practices. The researcher observed therapy sessions without intervening in the process, focusing to catch the natural interactions, methods, and engagement strategies used with patients. Participants were selected from multiple locations including clinics, schools, and online therapy platforms. The questionnaires included both closed and open-ended questions designed to gather perspectives on therapy effectiveness, accessibility, user satisfaction, and preferences between traditional and technology-based methods. By collaborating observational data, survey responses, and sessions therapy, this methodology aims to provide a holistic view of the current landscape of speech language therapy. It allows for the identification of key strengths, limitations, and potential opportunities for integrating traditional and technological approaches in the treatment of language disorders.

7. Structure of the Dissertation:

This dissertation is composed of three main chapters, each building toward a comprehensive understanding of language therapy in the context of developing technological advancements. The first chapter provides a thorough theoretical framework by reviewing the nature of language and speech disorders, traditional methods of therapy, and the role of feedback in treatment. It explores various types of language difficulties and the conventional approaches used by speech-language pathologists to support patients with communication impairments. The second chapter focuses to the impact of modern technologies and artificial intelligence on language therapy. It discusses the historical evolution of therapeutic tools, examines current AI-powered applications, and highlights both the potential and challenges associated with these digital innovations. This chapter also considers ethical concerns and proposes the possibility of integrating these tools with traditional methods. The third chapter utilizes descriptive analysis to interpret the qualitative and quantitative data gathered from the fieldwork within a case study design with the details of the therapy sessions. This chapter includes a selected treatment and challenges.

The dissertation uses a descriptive and comparative approach to interpret both theoretical research and practical observations, eventually offering valuable insights into the integration of technology and AI tools in speech-language therapy and their effectiveness alongside established clinical methods.

8. Delimitation of the Study:

This dissertation is delimited to exploring the success and integration of traditional and technology-based language therapy methods, with a certain focus on speech and language disorders and finding some solutions about these problems. The study centers on the educational and therapeutic implications of technology in language learning, instead of its development or engineering aspects. Also, examine the interventions related to speech production, language comprehension, and expression; in addition, we expand to large areas such as general cognitive development or psychological disorders. Searching data and tools currently in use to rich the study.

Chapter One: Language Therapy and Language Disorders

Introduction

Language therapy is crucial for academic success and mental health. It can help you improve your early language skills especially children, and helps to clarify your expressions. It considers consulting a healthcare for a good communication.

Language therapy is a usage that improves your ability to talk and use other language skills. Speech and language influence on the ability of people not only to communicate but also to acquire new knowledge and participate fully in society.

Speech and language therapy incorporate the science of medicine with building the meaningful human relationships and their speaking skills. Language therapy enables you to effectively express your thoughts and helps to communicate your ideas clearly; also, improving your ability to understand and interpret what others are saying.

Therapy is a process which is focusing on the management of contingent relations between antecedents, answers, and consequences of the communication attempt, or manipulating pragmatic communication interactions among the speaker, listener, and environment.

Language therapy gives a lecture to speech and communication disorders in various populations, including children with developmental language disorders (DLD), and those with psychiatric conditions like schizophrenia.

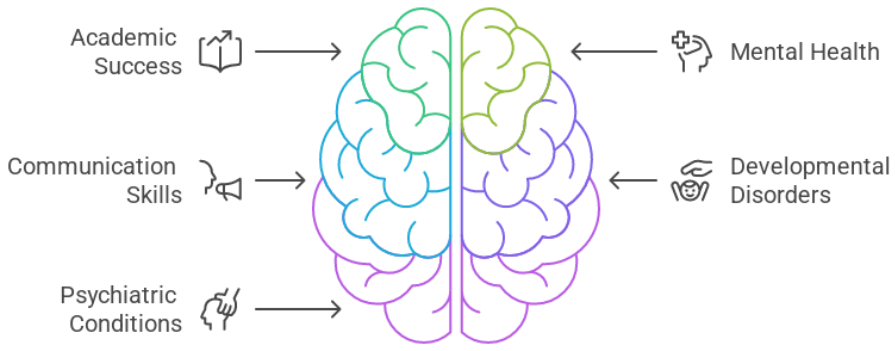


Figure I.1: The Components of Language Therapy

I.1.Language Problems and Disorders

I.1.1. Definition of Language Disorder

A language disorder (aphasia) is a way how it affects a child comprehends or uses language that makes it difficult to read, write, or speak. Language disorders are usually developmental disorders that start in early childhood. About 5% of children are diagnosed with language disorders between the ages of 3 and 5. These disorders affect all forms of communication and child's performance at home, in school, and in social situations that will have problems in learning all languages and he will use incorrect words to express things.

Language disorders reveal in early childhood; however, symptoms may not be obvious until later when a child begins to be exposed to more complex language. Symptoms can range from mild to intense.

I.1.2. Diagnosing Language Disorders

Language disorder diagnosis starts with a pediatrician decision by hearing problems or other distinct impairments that could impact language, then evaluates the child's ability to comprehend and express language. The speech language pathologist (SLP) will conduct standardized tests to observe how the child: listen, speaks, follows directions, repeats phrases or rhymes, understands names of things, performs other language activities. Children who have language disorders during primary school ages may present with the reading disorder in the future and learning difficulty. Struggle with academics and socializing with peers; also, functioning independently and behavioral problems. Social anxiety, difficulties interacting with others and building relationships, and other mental problems (Cleveland Clinic, n.d.).

Figure I.2: Diagnosis of Language Disorders

I.1.3. Speech Disorders:

Speech therapy may help with speech disorders in:

I.1.3.1. Stuttering:

Stuttering is also called childhood-onset fluency disorder. Most children outgrow this speech disorder; however, it can continue into adulthood. Symptoms include word prolongations, repetitions, pauses in one expression, broken words, and more issues. Their causes are not understood, but evidence suggests that atypical brain wiring—not underlying anxiety—is the origin cause. Although there is not a cure for stuttering, speech therapy and cognitive behavioral therapy may help patients who stutter speak with more fluency.

I.1.3.2. Apraxia:

Apraxia is a neurological disorder. Caused by damage parts of the brain that regulate motor planning which is an essential function on the brain processes. It gives information to prepare for

movements like forming words with your mouth to speak, make a conversation, or receive expressions. This disorder includes ideomotor, ideational, limb-kinetic, buccofacial, verbal, constructional, and oculomotor apraxia which are interfere with the ability of a human to perform everyday tasks and movements (Coelho, 2024).

Apraxia damages the left side of the brain, especially from stroke, traumatic brain injury, or dementia. But speech therapy can be used to help regain function and these disorders.

I.1.3.3. Voice:

Voice disorders can be permanent in terms of severity and duration, ranging from acting issues to long-term conditions that can make speaking difficult. Chronic voice disorders have a variety of conditions, such as: chronic cough, vocal fold paralysis, vocal polyps, spasmodic dysphonia. Treatment for these conditions of voice disorder often involves a combination of voice therapy, medical intervention, and sometimes surgery. It depending on the specific disorder.

I.1.3.4. Dysarthria:

The muscle weakness is the cause that makes speech difficult for individuals to control the muscles needed to talk. It has various neurological conditions that influence the brain's ability to control muscle movement. This disorder can occur as a result of other factors as the cerebral palsy, multiple sclerosis, or amyotrophic lateral sclerosis (ALS). It affects speech clarity which can impact their social interactions, emotional well-being, and quality of life.

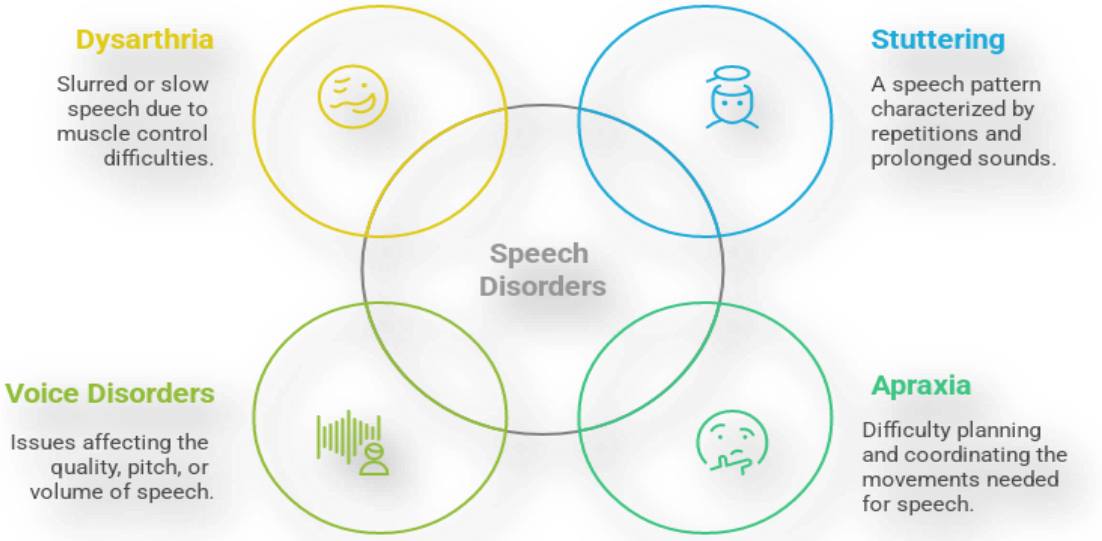


Figure I.3: Speech Disorders and Their Impact

I.2. Types of Language Problems and Disorders:

I.2.1. The Main Types of Language Problems and Disorders:

There are three different types of language disorders:

I.2.1.1. Receptive Language Disorder:

Children with receptive language disorder have difficulties in understanding language that they find it hard to follow conversations or instructions because they fight to comprehend words they hear or read, as well as what others are saying. This is making communication more difficult for both them and those around them.

I.2.1.2. Expressive Language Disorder:

Children with this disorder have no issues understanding what others say. These children usually fight to articulate their thoughts, feelings, needs, and express ideas clearly, which make it difficult for them to engage in meaningful conversations or express their thoughts in a way that

others can easily understand. This disorder creates serious problems in a child's ability to communicate effectively with friends, teachers, and other people.

I.2.1.3. Mixed Receptive-Expressive Language Disorder:

Children who have both receptive and expressive language disorders in the same time face a unique and more complex set of challenges. This dual disability creates a negative important barrier to effective communication, making it hard for them to follow conversations, understand orders, or engage in social environment. These children need specialized support and we must help them develop their both receptive and expressive language skills, as well as strategies to cross social interactions more helpfully (American Speech-Language-Hearing Association [ASHA], n.d.).

I.2.2. Types of Language-Based Learning Disabilities:

Language-based learning disabilities can manifest in various ways which are:

I.2.2.1. Dyslexia:

Dyslexia is one of the most common based-learning disabilities. Dyslexia is a language-processing disorder meaning that affects human's ability to read, write, and express language. This disorder has difficulties with decoding words, which involves breaking down words to individual sounds (phonemes) ;then, matching those sounds to letters or groups of letters. As a result, people will have a poor reading fluency and comprehension difficulties**;** also**,** have challenges with tasks that require to recognizing individual sounds within words, known as Phonemic Awareness**.** Dyslexia also affect Rapid Visual-Verbal responding**,** defining that an individual may have trouble associating a visual symbol with the spoken word or sound on time, leading to slower reading and verbal responses (Cleveland Clinic, n.d.).

The disorder is not related to intelligence, which means that patients with Dyslexia are usually have normal or above-average intelligence**,** but face challenges in specific areas of language processing. Genetics play a role in dyslexia disorder. Although, it is found in childhood, and may persist into adulthood; however, early identification and intervention help children with dyslexia succeed by utilizing a multi-sensory approach on the brain's ability to process language

and improve reading skills. With some supports, dyslexia can achieve academic success and successful challenges associated with this disorder.

I.2.2.2. Dysgraphia:

While dyslexia impact reading and language processing, dysgraphia is a neurological condition that involve difficulty turning their thoughts into written language for their age and ability to think. A person with dysgraphia may have problems with his writing, such as forming letters, maintaining consistent spacing between words, and organizing their ideas on paper. This person speak more easily and fluently than he writes while he may have more issues like letter formation and legibility, letter size and spacing, spelling, fine motor coordination, rate or speed of writing, grammar, and composition. This disorder presents troubles knowing when to use lower- or upper-case letters; also, struggling to form written sentences with correct grammar and punctuation. A patient with Dysgraphia has difficulties with holding, controlling a writing tool, and writing in a straight line. He does sentences with incorrect ordering words (Frontiers, n.d.).

Dysgraphia is more common in boys as it affects children and adults with many neurodevelopmental conditions. It goes undiagnosed or misdiagnosed and this caused on 5% to 20% of people have dysgraphia. So, early testing is important for learning differences. Children can learn new writing strategies sooner when Dysgraphia is diagnosed early. It is not mean that we are late to get a diagnosis and help. Schools may recommend an evaluation for learning disabilities with a certified educational psychologist to help finding these disorders earlier. Although Healthcare providers may use formalized handwriting assessments, beery developmental test of Visual Motor Integration (VMI) as assessments to check for eligibility for special programs. Occupational therapy and specialized teaching strategies may serve in improving writing skills and helping patients with dysgraphia find ways to advance in academic and professional settings (Radhakrishnan & Uttekar, n.d.).

I.2.2.3. Dyscalculia:

Dyscalculia is a learning disability that affects specific cognitive functions related to processing information. It has an impact on a person’s ability to understand number-based information and math because their brains don’t process math-related concepts as the brains of

people without Dyscalculia. Symptoms of this disorder are usually appear in childhood, they usually face mental health issues when they have to do math, such as anxiety, depression and other complicated feelings. They also may show emotional symptoms when look on with situations where math is necessary. Those emotional symptoms often include anxiety, agitation, fear, and physical complications. Experts estimate that Dyscalculia affects between 3% and 7% of people worldwide. This disorder involves difficulties in some areas of the brain that work together to solve a problem which are visual processing, short-term memory, language Long-term memory, understanding of quantities and amounts, calculation.

Dyscalculia does troubles that they understand the basic concepts; however, they may have difficulty applying them in more complex mathematical operations, such as addition, subtraction, multiplication, or division. Also**,** learning arithmetic facts is a difficulty for who have this disorder. While people learn multiplication tables, addition, and subtraction facts through practice, those with dyscalculia find it hard to memorize these basic facts, which may interfere with their ability to produce more advanced math operations (Radhakrishnan & Uttekar, n.d.).

With treatment and the right support, specialized learning programs, and interventions, patients with dyscalculia can learn strategies to compensate for their difficulties. Many children can develop their skills and their abilities that restrict how much this disorder impacts their lives. For adults who learn they have this condition, treatment is not possible; however, there are tools and ways to compensate for this condition like technology calculators or math apps which can provide tools for performing calculations and reinforcing math skills.

I.2.2.4. Auditory Processing Disorder (APD):

APD is a hearing issue that makes it hard for a person to understand what people are saying. Even though the ears may be functioning normally; however, the brain has difficulties in processing and interpreting sounds, it is a problem of the brain how interprets auditory signals. APD is confusing the order of sounds. Patients may have difficulty misinterpret sounds that occur close together in time and this make it hard for them to follow verbal instructions or understand speech in noisy environments, where multiple sounds are competing for attention. This led to misunderstandings, and difficulties in social or educational settings. This APD make a weakness

in some areas of human's body which are auditory discrimination, auditory figure-ground discrimination, auditory memory, auditory sequencing.

In APD, something keeps patients' brain from processing or interpreting the signals that their auditory nerve sent. When that happens, their brain misinterprets signals and they have trouble understanding what is being said. Another problem which is the incapacity to filter between different sounds. Auditory Processing Disorder (APD) may affect various aspects of communication, including listening comprehension, reading, and spelling. They may also find it hard to follow spoken conversations or comprehend complex verbal instructions. This can develop anxiety or depression because of these reasons (Mileham & Cercone, n.d.).

Doctors link this disorder with issues. Some of these issues are central nervous system disorders like stroke, epilepsy, multiple sclerosis or Alzheimer's disease; also, genetics, APD runs in families, frequent ear infections, head injuries, low birth weight or premature birth. Getting specialized speech therapy is a good treatment that focuses on building auditory skills. Additionally, using coping strategies, as a recording device to catch a communication or asking for more information. . Teachers and therapists can also use strategies such as visual cues, repetition, and simplified language to help patients with APD better understand spoken information (MedicineNet, n.d.).

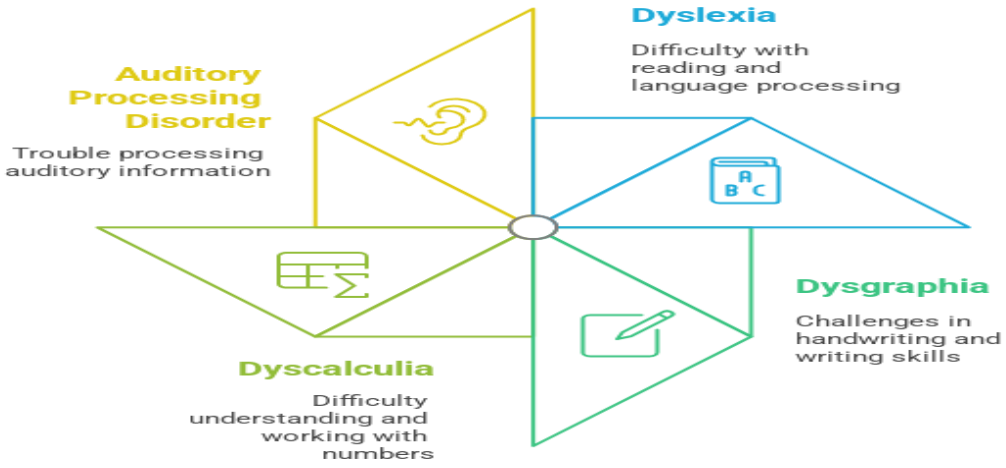


Figure I.4: Language-Based Learning Disabilities

I.2.3. Articulation and Phonological Disorders:

I.2.3.1. Articulation disorder:

Articulation disorder refers to the physical process of creating speech sounds, which involves the coordinated movement of lips, tongue, teeth, palate (the roof of the mouth), and the respiratory system (lungs). There are many different nerves and muscles used for speech. these muscles and nerves involved help control their precise movements during speech production. Lips are essential for producing sounds like "p" and "b". Tongue is involved in sounds such as "t" and "d". Teeth and palate help shape sounds like "s", "sh", and "ch.". The lungs provide breath needed to create sound vibrations in the vocal cords.

Articulation disorders include a variety of speech problems such as mispronunciations of sounds and inability to produce certain sounds means that cannot be able to produce certain sounds at all**;** for instance, a child may not be able to make the "r" sound, leading to words like "abbit" for "rabbit" or "rest" for "est". This difficulty could involve specific sounds like "r", "s", "l", or "th" which may be essential for a clear speech (The Royal Children's Hospital Pediatric Rehabilitation Service & Speech Pathology Department, 2018).

Articulation issues can occur with some reasons such as physical factors, muscle control issues related by apraxia of speech, hearing loss, and speech development delays. Children with articulation disorders need speech therapy to help them correct their speech sounds and improve their communication skills with home practice making them fun to learn more than the normal and capture it easily; however, parents should be practicing their children at the right level and putting them reminders. Early intervention may help prevent frustration or social challenges, as clear speech is critical for academic success, social interactions, and self-confidence.

I.2.3.2. Phonological Disorder:

Phonology refers to the system of sounds in a language and how those sounds are organized and used to create words. It is the structure of sounds which has the rules that guide how sounds combine to form words, syllables, and phrases.

A child with phonological disorder can produce individual speech sounds correctly, but he has difficulty with how and when to use them within words. Children with a phonological disorder make errors with specific sounds in words, even they can say them correctly in other contexts. A child substituting one sound for another incorrectly, which is common in children with a phonological disorder; for example, he replaces the sound ‘k’ with ‘a’ or ‘k’ with ‘t’.

Phonological disorder can affect many aspects of speech, not just a single sound. People cannot easily understand children with this type of disorder, especially if the errors are extensive across many different sounds. Patients with phonological disorders may benefit from speech therapy or phonological awareness training, where they can work with a speech-language pathologist (SLP) to learn and construct the right sound patterns and courses. Therapy may help recognize the rules of sound patterns in words, practice using the correct sounds in the correct positions, and develop a better understanding of how speech sounds work together to form words and sentences as well early intervention is more important can improve the ability to produce sounds in the right order, understand sound patterns, and develop the skills needed for successful reading, and writing (The Royal Children's Hospital Pediatric Rehabilitation Service & Speech Pathology Department, 2018).

I.2.4. Ankyloglossia (Tongue Tie):

It is a condition present at birth that impairs the tongue's range of motion. The evaluation and treatment of this condition concerned with multiple specialties in both medicine and dentistry. The International Affiliation of Tongue-Tie Professionals defines the lingual frenulum as a midline tissue remnant connecting the tongue's ventral surface to the floor of the mouth. Signs and symptoms of tongue-tie include difficulties in lifting the tongue to the upper teeth or moving the tongue from side to side, trouble sticking out the tongue past the lower front teeth, and a tongue that looks notched or heart shaped when stuck out (Messner et al., 2020).

If a child has trouble breastfeeding or complains of tongue problems that interfere with eating, speaking or reaching the back teeth, parents have to see a doctor for their child. This Ankyloglossia can lead breastfeeding problems, speech difficulties, poor oral hygiene, or challenges with other oral activities. We also know that there are letters in the Arabic language that are not found in English language, such as the letter "ق" and "س"which are difficult for children to pronounce; so, they replace these letters with the letters "أ " and "ث" (e.g., they say "الم" instead of "قلم" and "تكر" instead of "سكر").

It is important to differentiate between *frenotomy*, *frenuloplasty*, and *frenectomy*, as these terms are usually used changeable. *Frenotomy* (or *frenulotomy*) involves making an incision in the lingual frenulum and is commonly performed on infants. *Frenuloplasty* necessitates cutting the lingual frenulum and repositioning the tissue to admit for better mobility. Int the contrary, *frenectomy* refers to the complete removal of the lingual frenulum (World Health Organization [WHO], 2018).

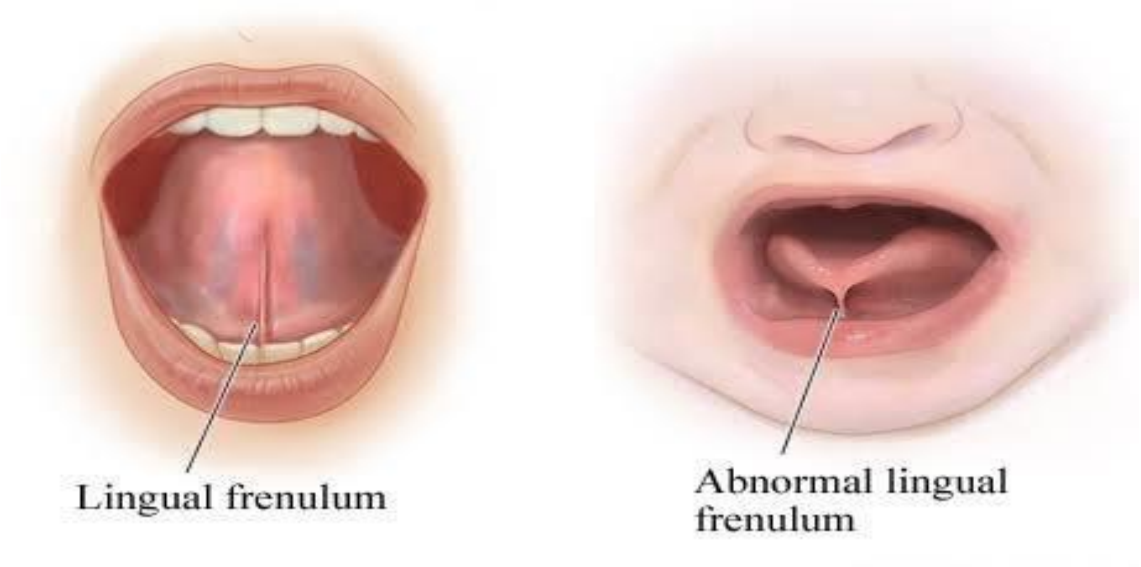


Figure I.5: Babies with Tongue-Tie

I.3. Traditional Approaches to Language Therapy:

For students with articulation disorders, the essential objective is to help them master the target sound and allow them to consistently make it accurately during conversations with various

speakers in a range of environments. The main goal is to make sure they can use the sound correctly in different contexts and communication situations.

I.3.1. The Traditional Articulation Therapy Approach:

The traditional articulation approach was developed by **Van Riper** in 1978. This approach usually used by Speech-Language Pathologists (SLPs), is designed to help children with articulation disorders to produce target sounds correctly. This SLPs works on one sound at a time and advancements to working on the sound in isolation, words, phrases, sentences, reading, syllables, and conversation. The process follows a hierarchical or vertical method, where the sound is worked on one position at a time. When the child can correctly make the sound in isolation, therapists move on to practicing it in syllables (e.g., "ba", "pa", "ka"), then in words (e.g., "ball", "cat", "pen"). From there, the sound is practiced in phrases (e.g., "I see the ball") and sentences (e.g., "The cat is coming"). They finish with a step which is practicing the sound in reading and talking, where the child uses the sound naturally in daily speech with different persons in various situations. The goal is to help children integrate the right sound into their daily speech, making it a permanent part of their language use. In addition, children will have a good treatment about speech disorders such as Ankyloglossia which is the most controversial between these speech and language disorders (The Dabbling Speechie, 2019).

This approach focuses on teaching children the impose motor movements needed to produce the target sound rightly with the phonetic placement aspect. The SLPs will work on helping children understand how to position their tongue, lips, teeth, and breath to correctly make that sound. With practicing and focusing on motor skills speech sounds of patients involve precise coordination of muscles in their mouth and vocal tract.

This approach gives structure and incremental development, allowing the patient to build confidence and knowledge step by step. Each level of his practice helps reinforce the right motor movements needed to make the sound, and as the child progresses, he develops the ability to use the sound more naturally and perfectly in his daily speech. It also allows children to generalize the right use of the sound across different settings and with various speaking partners, which is decisive for ensuring that the progress is maintained and that children may effectively

communicate in real-world contexts. They control their articulation difficulties and improve their clarity of speech (Messner et al., 2020).

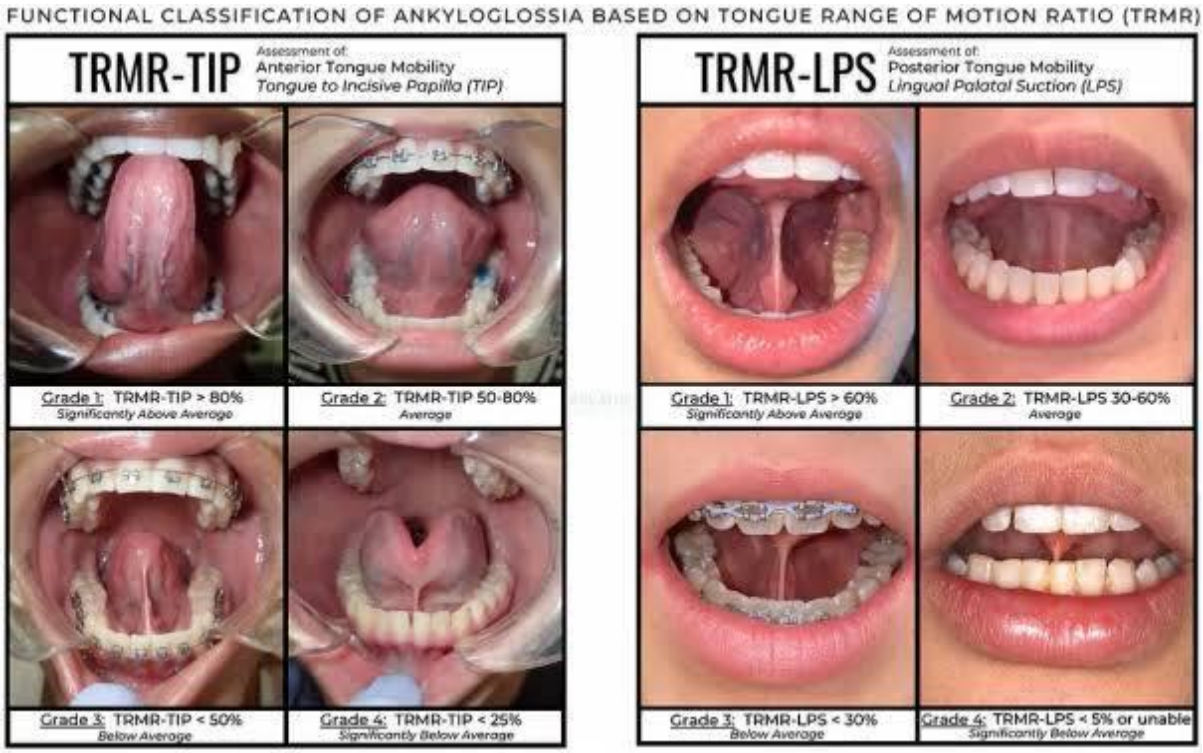


Figure I.6: Tongue Range of Motion Ratio

I.3.1.1. Five Steps in Van Riper's Traditional Therapy Method:

Discrimination Training – Can they hear correct vs. incorrect productions of the sound?

Stimulability is the student able to correctly produce the sound when given prompts for the

Sound Stabilization – The child expands the contexts in which he or she can correctly say the sound.

Generalization – when the child is able to correctly produce the sound, regardless of the environment or the person to whom he or she is speaking.

Maintenance – monitoring the child's speech over time to ensure that he or she is continuing to correctly produce the correct sounds in all contexts of conversation (Van Riper & Erickson, 1996).

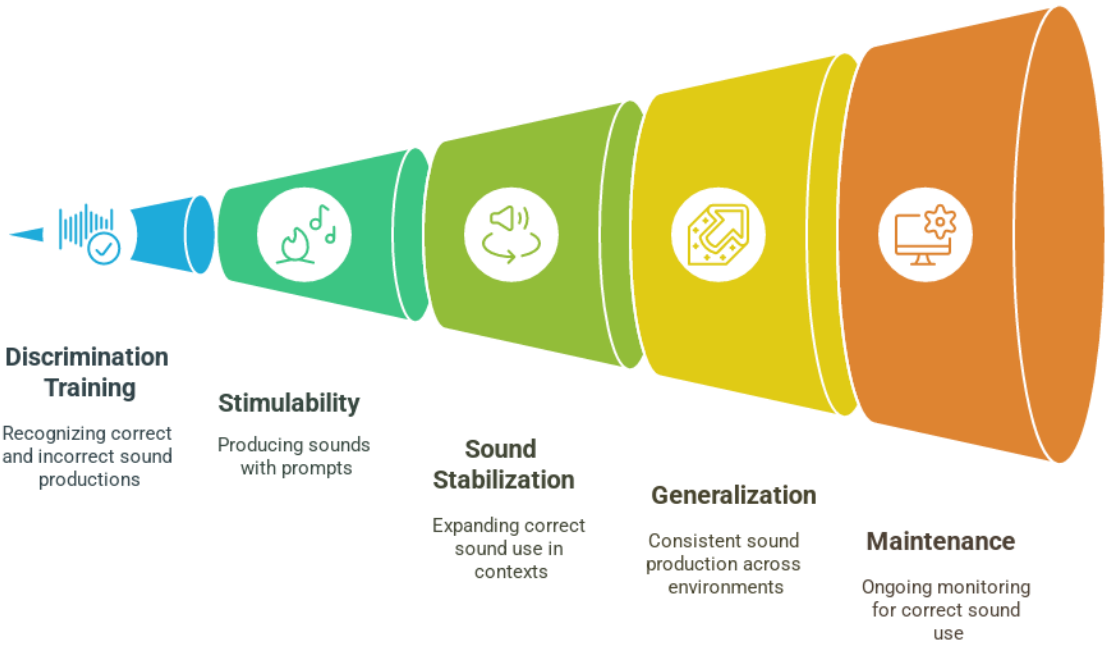


Figure I.7: Speech Sound Mastery Process

I.3.2. Discriminating between Error and Target Sound:

At the early stage of therapy for children with articulation disorders, the focus is often on developing the child's awareness of speech sounds and how they are produced, rather than requiring the child to immediately make the correct sound. This level is crucial since the child doesn't yet have to worry about physically making the right sound; by contrast, they are simply assigned with identifying whether the sound they produced was correct or incorrect.

This process is mentioned to as a metalinguistic task, which means the child is engaging in a higher-level cognitive activity that means thinking about language. Metalinguistic awareness

refers to the ability to give back on and manipulate language as an object, rather than just using it to communicate. In this setting, the child is learning to think about sounds and their patterns in a conscious, deliberate way, which may be a powerful method for language learning.

Metalinguistic functions help build a strong foundation for language development since they require the child to analyze and evaluate language, which is an essential step in improving their ability to make right speech sounds. By simply judging whether their sound was right or or not, the child is becoming more aware of the sound structure of words and how individual sounds fit together to produce words meaningful. This awareness is a reproving first step in mastering the motor skills needed to make those sounds perfectly.

Once the child has advanced the ability to recognize and pinpoint errors in their speech, they are prepared to advance to the next level of therapy, which focuses on producing the right sounds (Williams et al., 2010). This heightened metalinguistic awareness plays the groundwork for the subsequent steps, where the child will focus on the physical movements necessary to make those sounds rightly. By initially honing their ability to identify speech errors, the child is better prepared to understand and practice the motor skills required for proper articulation. This foundational realization not only supports more effective learning of right sound production; however, it helps the child seamlessly incorporate these sounds into their daily speech, allowing them to communicate more easily, clearly and naturally over time.

I.3.3. Stimulating Speech Sounds and Phonetic Placement:

This approach is generally used in speech therapy, especially for young children, as it focuses on teaching proper articulation through physical demonstration. The method is helpful in helping children learn how to make speech sounds rightly by guiding them on how to position their tongue, teeth, lips, and other articulators (parts of the mouth used to produce sounds). The articulators play a crucial role in shaping the sounds created by the vocal cords.

Doctors might also use a combination of visual, tactile, and verbal cues to hold up the right positioning. For example, doctors might place the child's hand on their own throat or face to feel the vibrations of the articulators as the sound is produced. This direct, hands-on approach permits the child to understand the physical aspects of speech production, which is usually necessary for

children who are still developing the fine motor skills required to make speech sounds perfectly. For instance, if a child is struggling to produce the "s" sound, doctors might demonstrate how to position the nearly tongue the roof of the mouth just behind the teeth and how to direct the airflow over the tongue without touching the teeth. By learning the right tongue, lip, and teeth placements. Children may begin to develop the muscle memory needed for consistent and right sound production.

These methods help children become more aware of the sensory feedback involved in speech. As they produce the sound, they can feel the air moving in a particular way or notice the position of their tongue and lips, which reinforces the connection between their physical movements and the right production of sounds. This approach not only promotes better sound production; however, also builds a strong foundation for clear speech, ensuring that children will be able to use these sounds rightly in various speaking situations as they grow and develop their language skills (Allen, 2013).

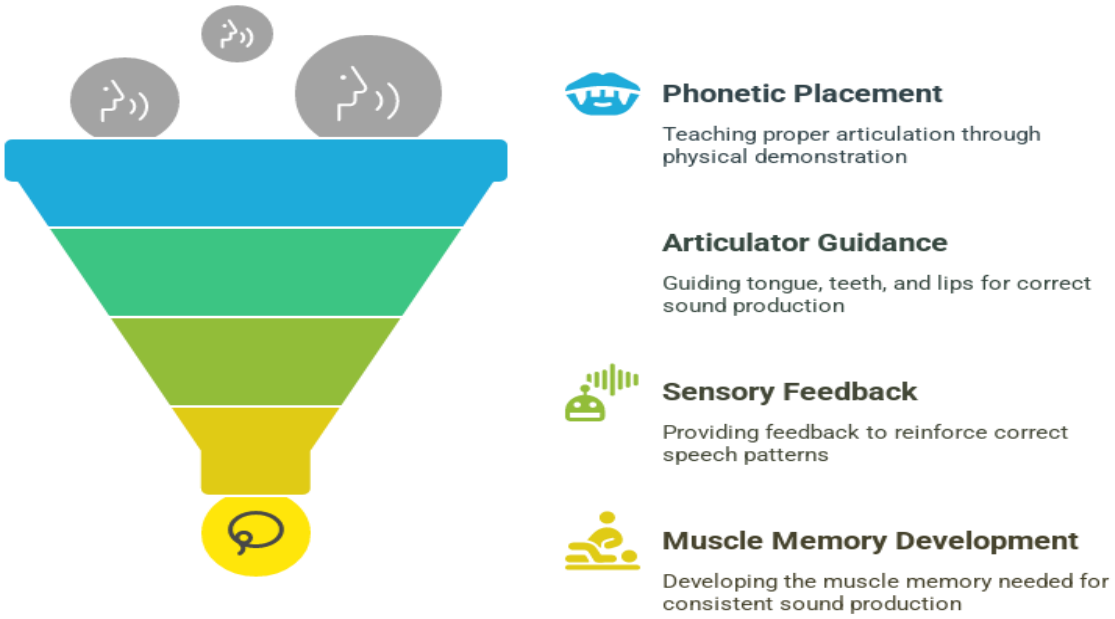


Figure I.8: Building Speech Articulation

I.4. The Role of Feedback in Language Therapy:

Feedback can be both summative and formative. Feedback is nearly always to some extent judgmental and it is intended to serve both purposes, but how feedback is given will rely on the relative importance that is given to these large purposes. It is typically evaluative to some degree, as well as it often serves multiple purposes. This formative feedback in language learning, specially emphasizing its role in guiding learners on the way to improvement, rather than simply evaluating their happening performance.

I.4.1. Judgmental Nature of Feedback:

In practice, feedback, by nature, is a little bit judgmental. This means feedback commonly involves some form of evaluation, such as determining whether a learner's response was correct or incorrect. However, feedback is not always about completely assessing; it may also guide or motivate learners to improve (Pritchard, 2022). The way feedback is provided depends on the correlative importance of its purpose. Whether the main goal is to help the learner improve, push their motivation, or promote autonomy.

I.4.2. Formative Feedback vs. Summative Feedback:

This feedback is specifically concerned with formative feedback which is a type of feedback that focuses on supporting the learner's ongoing development. Formative feedback is marked out as "feed forward" since it does not just evaluate past performance; however, provides insight into what the learner may do next to improve. In other words, formative feedback helps learners understand how they can move forward in their learning journey, giving them practical advice or next steps.

I.4.3. Error Correction (Corrective Feedback):

One of the most common forms of feedback in language classes is error correction, also known as corrective feedback. This kind of feedback peruses to correct learners' mistakes, helping them make better their accuracy to give them the ability to use language rightly. For instance, if a pupil makes a grammatical error, the teacher might correct him to help him understand the mistake

and learn the correct form. However, while error correction is an essential tool in language learning, this feedback should be understood in a wide context, beyond just correcting mistakes (Helping Hands Therapy Services, n.d.).

I.4.4. Three Fundamental Purposes of Feedback:

I.4.4.1. Improving Fluency, Accuracy, or Complexity:

Feedback helps learners increase their speaking and writing by making their language use more able to be easy, accurate, or more sophisticated in structure or vocabulary. These improvements are key for powerful communication (American Speech-Language-Hearing Association [ASHA], n.d.).

I.4.4.2. Motivating Learners:

Feedback must serve as a source of motivation for learners. It should encourage them to keep improving and progressing in their language learning, especially when they look out on difficulties. Motivational feedback helps learners' confidence and make them stay engaged with the learning setting.

I.4.4.3. Developing Learner Autonomy:

An important function of feedback that is helping learners become more liberated in their learning. Learner autonomy mentions to the ability of learners to take responsibility for their own learning process. Feedback encourages this autonomy might suggest strategies for self-correction, ways to practice independently, or give tools for learners to monitor and improve their language skills without continual external guidance (National Institute of Neurological Disorders and Stroke [NINDS], 2021).

Figure I.9: Controling Learners

I.5. Immediate Feedback:

Real-time feedback during therapy sessions is one of the most powerful features of live audio analysis. It produces an immediate feedback curve, fostering an interactive learning atmosphere where patients can make adjustments and developments on the spot, rather than relying on delayed feedback. This dynamic environment lets for more effective learning and speedy adaptation, as patients receive instant guidance to clarify their skills in real-time.

With conventional methods with patients, therapists need to listen, assess and then make oral feedback regarding the production. After that, view visual representations of the sound production as it happens, compare the patient's production with target models instantly, make immediate adjustments based on objective feedback, and track improvements within the same session. This immediate feedback process creates a more engaging and essential learning experience. Patients may see their progress in real-time, which leads to improved motivation and better outcomes. Research has seen that immediate feedback in speech therapy can significantly accelerate the learning process and help patients develop better realization of their speech patterns. For example, when working with a young patient on key control for voice therapy, phonalyze real-time key tracking allows them to visualize their voice modulation instantly (Walsh & Tunkel, 2017). This visual feedback helps them understand and adjust their key more successfully than verbal instructions alone.

I.6. The Importance of Feedback:

Children with speech sound disorders are greatly benefit from feedback that helps them understand the accuracy of the sounds they make. This feedback, regularly provided by speech pathologists, is vital for helping children correct their speech patterns. Also, home practice plays an essential role in reinforcing the lessons learned during therapy sessions. While mobile applications and other technology methods such as Artificial Intelligence (AI) is a set of latest technologies that authorize computers to perform a variety of advanced functions. About home practice, it can motivate children through engaging games, most available applications are limited in their effectiveness. They fail to provide detailed feedback, such as elaborating on why a sound is correct or incorrect as well as offering specific guidance on how to improve sound accuracy. Without this level of feedback, these applications may not significantly aid in the correction and concentration of speech sounds (Isaacson, 2024).

Conclusion:

While real-time feedback is indispensable in therapy sessions, enabling patients to adjust and adapt immediately, many digital tools are not equipped to offer the nuanced guidance required for substantial progress. In addition, speech sound disorders such as dyslexia, dysgraphia, and dyscalculia, as well as more complex issues like auditory processing disorders and articulation disorders, present unique challenges for both learners and educators, requiring adapt approaches for each condition. As technology advances, integrating more personalized, detailed feedback into therapeutic practices might help bridge the gap between in-person therapy and at-home practice, improving general outcomes. Therefore, while language therapy lives on a vital resource, ongoing advancements in both therapeutic techniques and digital tools will be essential for enhancing productiveness and supporting learners in overcoming their specific challenges.

Language therapy has a crucial role in addressing various speech and language disorders, it gives a way for patients, especially children, to improve their communication skills. Through formative feedback, therapy helps learners recognize areas of improvement and provides clear guidance on how to enhance fluency, accuracy, and complexity in speaking and writing. Although error correction is a primary method in language therapy, the feedback given should be more than

just corrective: It must also be motivating and encourage learner autonomy, enabling patients to get hold of charge of their learning journey. However, challenges persist, particularly in the use of mobile applications for home practice, which, despite their potential, a lot of lack the depth of feedback needed to promote significant improvement in speech sound disorders.

CHAPTER TWO:

The Role of Technology and AI in Language Therapy

Introduction

Language therapy has long been a crucial field in addressing speech and communication disorders, yet traditional methods often face challenges related to accessibility, consistency, and personalization. With the rapid advancement of technology, particularly Artificial Intelligence (AI) and speech recognition, language therapy is evolving in ways that enhance both its effectiveness and reach. AI-driven tools can provide real-time feedback, personalized therapy sessions, and automated speech analysis, supporting therapists in delivering more precise and adaptive interventions. However, these technologies are not meant to replace human therapists but rather to serve as valuable tools that complement their expertise. Human interaction remains essential in language therapy, as therapists provide the critical emotional, cognitive, and contextual understanding that AI alone cannot replicate. This chapter explores the historical evolution of technology in language therapy, tracing its development from early assistive tools to sophisticated AI-driven applications. It also examines the ways AI and digital tools are enhancing traditional therapy practices, emphasizing their role as supportive aids rather than substitutes. By investigating these advancements, this chapter aims to provide a comprehensive understanding of how technology is transforming language therapy while reinforcing the irreplaceable role of human therapists in the therapeutic process.

II.1. The Evolution of Speech and Language Therapy

II.1.1. Traditional Approaches

Historically, speech and language therapy has relied heavily on in-person sessions, manual exercises, and paper-based materials. These traditional methods required therapists to invest considerable time preparing materials and conducting repetitive exercises with patients. While effective, these approaches often lacked the engagement and interactivity that technology can offer today. Early technological tools in this field were primitive by today’s standards but laid the foundation for the advanced interventions we use today.

II.1.1.1. Tape Recorders

One of the earliest technological instruments to be extensively employed in speech therapy was the tape recorder. Therapists started recording their clients' speech on reel-to-reel tape recorders in the 1950s. For kids with speech abnormalities including stuttering or articulation problems, this was especially helpful. patients were able to improve their speech patterns by being

more conscious of their speech patterns through the playback of their own speech. The recordings could potentially be used by therapists to provide targeted feedback and monitor improvement over time. This innovation marked a significant advancement in language therapy, as it introduced a more structured and systematic approach compared to traditional methods (The Development of the Tape Recorder, n.d.).

Figure II.1: Old Tape Recorder

II.1.1.2. Picture Boards and Communication Devices (1960s-1970s)

For children and adults who were non-verbal or had limited speaking ability, image cards and communication boards gained popularity in the 1960s and 1970s. These early technologies gave people another way to communicate by enabling them to use symbols or drawings. For people with severe speech problems, autism, and cerebral palsy, the usage of these boards proved essential (Beukelman & Mirenda, 2005). At this time, the first advancements in augmentative and alternative communication (AAC) technology started to take shape. The 1980s saw the development of one such gadget, the "Picture Exchange Communication System" (PECS), which had its origins in the previous image boards. It allowed users to share images in order to communicate thoughts, wants, or desires.

II.1.1.3. Computers and Software (1980s-1990s)

Personal computers in the 1980s, had a real impact on how speech therapy was practiced and its outcomes. Therapists subsequently started to bring computer-assisted learning (CALL) programs in the sessions for the purpose of interactive and entertaining language practice in

vocabulary spelling and grammar. Such programs aided children with language impairments very well since they were highly structured and indeed repetitive, so language practice happened often. Likewise, speech recognition technology grew in this era with vocabularies of a few hundred to tens of thousands of words. Statistical approaches, such as the Hidden Markov Model have improved the performance of these systems so a decent level of real-time feedback on what was actually said could be given by the computer. Which resulted in better accuracy of speech therapy for people with articulation disorders (Perkins, 1985).

II.1.1.4. Interactive Video Games

In the 1990s, interactive video games began altering language therapy because they established gamified learning environments. These environments enabled children to practice their communication skills. At the time, advanced speech recognition was not common. However, "edutainment" programs like Fast ForWord coped with auditory processing by teaching the child to process auditory stimuli and repeated language tasks (saying a passage from one screen to another). Additionally, memory challenges, vocabulary-building activities, and touch screen activities kept children engaged, while basic voice interaction was introduced to improve interactive and pronunciation skills (controlled by speaking certain syllables or words into a microphone) (Gillam et al., 2008). However, traditional interventions were not much more polished compared to modern systems and their feedback collection mechanisms. Research from this period showed that game-based technology could motivate children to practice articulation and improve phonological awareness. However, evidence-based digital interventions, clinically evaluated trials, and student learning outcomes data were limited in the 1990s. This changed in the 2000s when more sophisticated systems integrating speech analysis, adaptation, and other learning technologies became more common (Loeb et al., 2009).

Figure II.2: Interactive Video Games

II.1.1.5. Text-to-Speech Devices (Late 1990s - 2000s)

Text-to-speech (TTS) was incorporated into AAC devices in the late 1990s, enabling individuals with speech disabilities to transform text into synthetic speech. These devices were life-changing for individuals with conditions like aphasia, where reading and writing skills are mostly preserved but spoken communication is impaired (Wallace et al., 2022). First-generation TTS voices were robotic, but the user could input messages into the LightWRITER device for auditory output, providing users with a practical verbalization alternative. TTS voices had understandable limitations and high costs, but they significantly improved accessible communication at the time.

II.1.1.6. Early Speech Recognition Technology (2000s)

Advancements in speech recognition technology during the early 2000s significantly enhanced speech therapy tools. By this time, speech recognition accuracy had reached approximately 80% (Rotter, 2024). To satisfy the needs of speech therapy patients, voice recognition software such as Dragon NaturallySpeaking, was adjusted. People could practice fluency and articulation and get correct feedback from the system thanks to these technologies. Personalized voice quality, fluency, and articulation exercises can be included in early speech recognition software made specifically for therapy. Speech therapists can follow a patient's progress and change the exercise's complexity level in real time, leading to ideally customized and focused treatment plans.

Figure II.3: Dragon Naturally Speaking Headset

II.1.2. Modern Digital Tools in Therapy

The demand for more individualized, interesting, and adaptable therapeutic techniques is what is driving the movement in speech therapy toward digital technologies. SLPs now have access to a wide range of digital materials due to the growth of smartphones, tablets, and interactive software. These resources not only improve conventional therapeutic approaches but also create new opportunities for interaction and education.

On the basis of recent findings from Computational Language Assessment (CLA) studies—a term we use to refer to both AI and Computational Assessment tools—CLA can identify dementia symptoms early, track the progression of the disease, and assess the effectiveness of treatment (Themistocleous, 2023).

II.1.2.1. Mobile Applications for Language Intervention

Numerous applications are made to focus on particular skills including fluency, language development, and articulation. As mobile technology becomes more accessible, applications for tablets and smartphones are becoming more and more popular for this kind of treatment. Aphasia (language impairment) can be detected with apps that also help individuals with stroke and

traumatic brain injury complete their assignments more easily and adults with acquired cognitive problems with their cognitive abilities Apps like **Speech Blubs** and **Articulation Station** provide interactive exercises tailored to speech sound disorders. They often use gamification, AI-based feedback, and speech recognition to help users practice pronunciation.

II.1.2.1.1. Speech Blubs

Industry applications such as Speech Blubs provide AI-driven speech therapy exercises tailored for children, integrating video modeling and interactive activities to enhance language development (Blub Blub Inc., n.d.). It aims to help children experiencing speech delays, autism, or apraxia. It utilizes video modeling, allowing children to watch their peers pronounce words and motivating them to replicate those actions. The application employs speech recognition technology to deliver immediate feedback, reinforcing accurate pronunciation. Furthermore, it includes gamified features, like engaging mini-games and entertaining face filters, to sustain enthusiasm and motivation throughout practice sessions.

II.1.2.1.2. Articulation Station

Industry applications such as Articulation Station provide structured articulation exercises, allowing users to practice speech sounds through interactive activities and personalized feedback. It provides extensive materials for practicing particular phonemes across different levels, such as words, sentences, and narratives. Users have the ability to record their voice, listen to their pronunciation, and compare it with accurate examples, making self-assessment and corrections easier. The application offers interactive options such as flashcards and memory games, ensuring that articulation practice is both dynamic and efficient (Little Bee Speech, n.d.).

Feature	**Speech Blubs**	**Articulation Station**
Target Age	Children	Children & Adults
Focus	Speech delay, autism, early speech learning	Specific phoneme articulation
Technology	AI, video modeling, gamification	Phoneme-based exercises, playback
Best For	Encouraging verbal communication	Correcting specific speech sounds

Table II.1: Comparison of Speech Therapy Applications

II.1.2.2. Therapy software with interactive learning

Traditional approaches to speech and language therapy have been revolutionized by the incorporation of digital tools, which improve customization, accessibility, and engagement. TalkPath Therapy and Tactus Therapy, two popular therapy software packages, offer interactive learning solutions for people with communication disorders, especially those recuperating from illnesses like apraxia, aphasia, and cognitive impairments.

II.1.2.2.1. LSVT LOUD

The incorporation of digital tools into speech therapy has greatly enhanced both accessibility and treatment outcomes. LSVT LOUD® Companion, as highlighted by LSVT Global (2019, May 17), provides individuals with Parkinson's disease and other neurological speech disorders the ability to engage in independent practice through real-time acoustic analysis and automated feedback. This innovative feature allows patients to track critical speech parameters such as pitch, loudness, and duration in alignment with the LSVT LOUD methodology (Ramig et al., 2018). By facilitating the patient's practice independently beyond the confines of the clinic setting, the incorporation of this technology has also proved to improve patient compliance and ensure the long-term continuation of speech gains. Evidence also shows the LSVT LOUD Companion substantially improves the intelligibility and loudness of speech for individuals with Parkinson's, proving to be a valuable adjunctive treatment when combined with traditional clinic-based treatment. The growing popularity of tools such as the LSVT LOUD Companion reflects the expanding presence of technology for the practice of speech-language pathology. These tools are particularly helpful for underprivileged groups or those remotely located, eliminating the disparities for access to specialized clinic treatment.

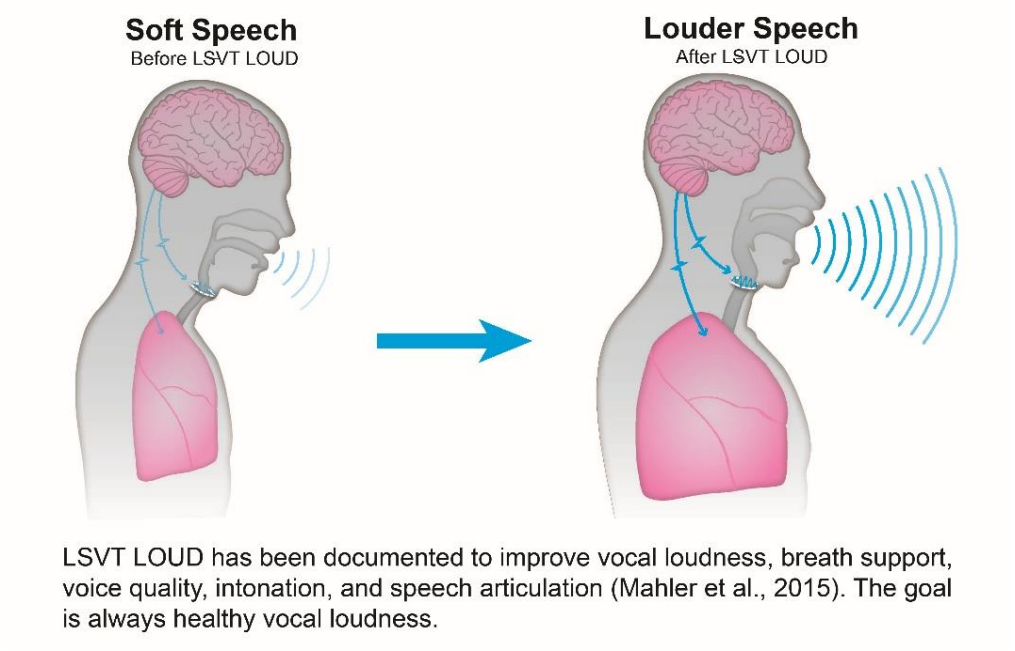


Figure II.4: LSVT LOUD Results

II.1.2.2.2. TalkPath

Applications developed by the industry, such as TalkPath Therapy from Lingraphica, provide users with access to more than 13,500 language and cognitive exercises designed to aid in the rehabilitation of speech and language skills (Lingraphica, n.d.). This online platform supports individuals with communication disorders, including aphasia and cognitive-linguistic challenges, by offering structured, evidence-based activities that focus on aspects such as auditory comprehension, naming, and reading. Users have the opportunity to practice independently and monitor their progress in real time (U.S. Department of Veterans Affairs, 2017). One significant benefit of TalkPath Therapy is its integration with telepractice, enabling speech-language pathologists (SLPs) to remotely assess patient progress and modify treatment strategies as necessary. Research underscores the essential importance of such platforms for patients in underserved or rural areas, as they facilitate access to therapy anytime and from any location (Simmons-Mackie et al., 2010).

Figure II.5: Interface of TalkPath Therapy

II.1.2.3. Virtual Reality (VR) Platforms for Immersive Speech Therapy

Virtual reality (VR) has emerged as a powerful tool in speech and language therapy, offering immersive and interactive environments that supplement traditional therapeutic methods. In VR-based therapy, patients can rehearse speech production, linguistic processing, and social communication abilities in secure and engaging scenarios that resemble real-life situations. These tools are shown to be helpful for people with speech-motor disorders, autism spectrum disorder (ASD), and aphasia by providing a secure and flexible place for repeated practice. VIRTUES (Virtual Reality for Aphasia Therapy) is a VR platform that uses real-life conversational practice to help stroke survivors with aphasia. Similarly, platforms like EVA Park provide virtual environments where individuals with aphasia can engage in conversational practice, leading to improvements in communication skills and social connections (Devane et al., 2022). For people with ASD, VR-based social communication training facilitates organized practice of verbal interactions, eye contact, and turn-taking in an interactive format (Maddalon et al., 2024). Data suggest that VR therapy increases patient motivation, engagement, and skill maintenance, making it an excellent companion for conventional speech therapy.

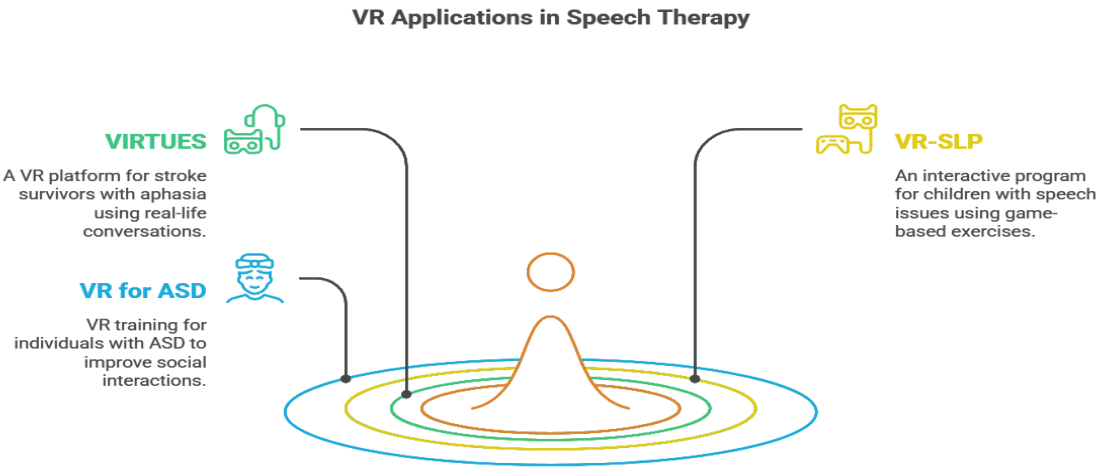


Figure II.6: VR Applications in Speech Therapy

II.2. Understanding AI and Its Applications in Language Therapy

Artificial Intelligence (AI) is everywhere nowadays and it is playing a crucial part in the recovery process of speech disorders. The incorporation of technological advances such as Machine Learning (ML), Natural Language Processing (NLP), and Speech Recognition and Synthesis is the most impactful in the field of language therapy. they are a key connecting point for both the therapists and the clients. These cutting-edge AI technologies assist in analyzing the speech patterns, training correct pronunciation, and giving real-time feedback; thus, language therapy becomes more accessible and productive.

II.2.1. Language Therapy Using Natural Language Processing (NLP)

Natural language processing (NLP) is a branch of artificial intelligence that enables computers to process, analyze, and understand human language (Rongali, 2025). In speech therapy, NLP algorithms help:

- Correction of grammar and syntax for people with language impairments.
- virtual assistants and chatbots that encourage users to practice having conversations.
- Using semantic analysis to evaluate speech production's coherence and meaning.

For instance, generative AI programs have been created to provide customized language practice and feedback to kids with particular language impairments (Qin, 2024).

However, NLP-based systems face challenges such as code-switching, linguistic ambiguity, and limited linguistic diversity in training datasets. The effectiveness of these systems depends on their ability to accurately interpret speech from diverse linguistic backgrounds, highlighting the need for further research and advancements in AI-driven language therapy.

II.2.2. Speech Recognition and Synthesis in Therapy

Technologies such as automatic speech recognition (ASR) and text-to-speech (TTS) are greatly improving language therapy by offering tools for evaluation, feedback, and communication aid. ASR helps in analyzing aspects like pronunciation, fluency, and articulation, which is advantageous for individuals dealing with conditions such as stuttering, aphasia, and dysarthria (Baker et al., 2022). Nevertheless, there are ongoing challenges concerning the accuracy and fairness in recognizing various speech patterns. TTS plays a role by providing auditory models, enhancing augmentative and alternative communication (AAC) devices, and customizing speech training to fit the unique needs of individuals (Liss & Berisha, 2020). Even with progress, concerns about the naturalness of synthesized speech and the extent of customization remain crucial. Future innovations, particularly in adaptive deep learning techniques and personalized synthetic voices, show potential for creating more effective therapeutic solutions, establishing AI-powered speech tools as essential elements in modern language intervention.

II.2.3. Machine Learning in Speech Therapy

Machine learning (ML) allows computers to learn from data and make decisions without being explicitly programmed (Alp Aydin, 2020). In speech therapy, ML models learn from speech databases and detect phonetic errors, fluency issues, and articulation errors by comparing them with linguistic standards. Speech therapy applications developed using AI provide personalized exercises and feedback to individuals suffering from speech sound disorders. However, it is difficult to apply these models to diverse accents and dialects, particularly non-standard speech patterns like those used in aphasia or dysarthria. The solution to these challenges lies in expanding datasets and reducing biases while training the model (Brahmi et al., 2024).

II.2.3.1. Varieties of Machine Learning Approaches in Speech and Language Therapy

Speech and language therapy has benefited greatly from machine learning (ML), which provides a variety of approaches for evaluating and categorizing linguistic data. The accuracy and efficacy of therapeutic interventions are improved by using a variety of machine learning techniques. These are the main machine learning paradigms and their particular uses in speech-language pathology:

II.2.3.1.1. Supervised Learning for Structured Language Training

Labeled data is used in supervised learning; Each training sample is mapped to a specific known category or outcome. From this structured dataset, the model learns to classify or predict outcomes for new data (Goodfellow, Bengio, & Courville, 2016). For example, a supervised learning model can be trained using a dataset of speech samples labeled with specific conditions, such as Specific Language Impairment (SLI), Dyslexia, or autism spectrum disorder (ASD). Detecting these linguistic patterns could facilitate early diagnosis and potentially assist in personalized treatment planning.

II.2.3.1.2. Unsupervised learning for Adaptive Content

Unsupervised learning enables AI models to work with raw, unmarked data, discovering patterns and structures without predetermined categories. This is helpful for revealing latent relationships in the speech and language data (Murphy, 2012).

Using vast-scale speech data, AI-powered unsupervised learning can be employed to identify subtypes of language disorders. For instance, it can detect unique phonetic traits in children with dyslexia, leading to more nuanced diagnostic categories and tailored intervention methods.

II.2.3.1.3. Semi Supervised Learning for Personalized Language Learning

Semi supervised learning combines labeled and unlabeled data to be effective in situations where there is a shortage of labeled data, for training AI models (van Engelen & Hoos 2020). This method allows AI models to identify patterns from a labeled dataset and apply them to a larger dataset where labels are unknown.

In speech therapy, a model trained on a limited labeled dataset of speech recordings (e.g., those from diagnosed speech disorders) can generalize its learning to a larger pool of unlabeled samples. This approach enhances diagnostic accuracy and helps identify previously undiagnosed cases of speech impairments.

II.2.3.1.4. Reinforcement Learning for Real-Time Feedback

Reinforcement Learning (RL) is about AI completing an arranged environment and gives it the rewards it gets for the right things and the penalties for the wrong ones. This method allows the model to get better at doing something over time, and in this way, it becomes very suitable for interactive speech therapy applications (Sutton & Barto, 2018).

For example, AI-supported therapy techniques can encourage reinforcement learning (RL) to help correct the pronunciation of individuals with sufficient data. If a patient struggles to produce the correct sounds, the system can automatically adjust the level of difficulty and provide additional practice, ensuring that the learning process continues effectively.

II.2.3.1.5. Transfer learning for Multilingual and Specialized Training

Transfer learning is a machine learning approach that allows an AI model to utilize knowledge acquired from one task to improve performance on a related task with minimal retraining (Pan & Yang, 2010). For example, start by collecting a large, diverse dataset of speech data, such as audiobooks and transcriptions. Train a base model on this extensive dataset. Afterward, fine-tune the pre-trained model for specialized speech-language tasks, like identifying speech disorders in individuals with aphasia. This optimized model enhances diagnostic accuracy and supports personalized therapy for patients.

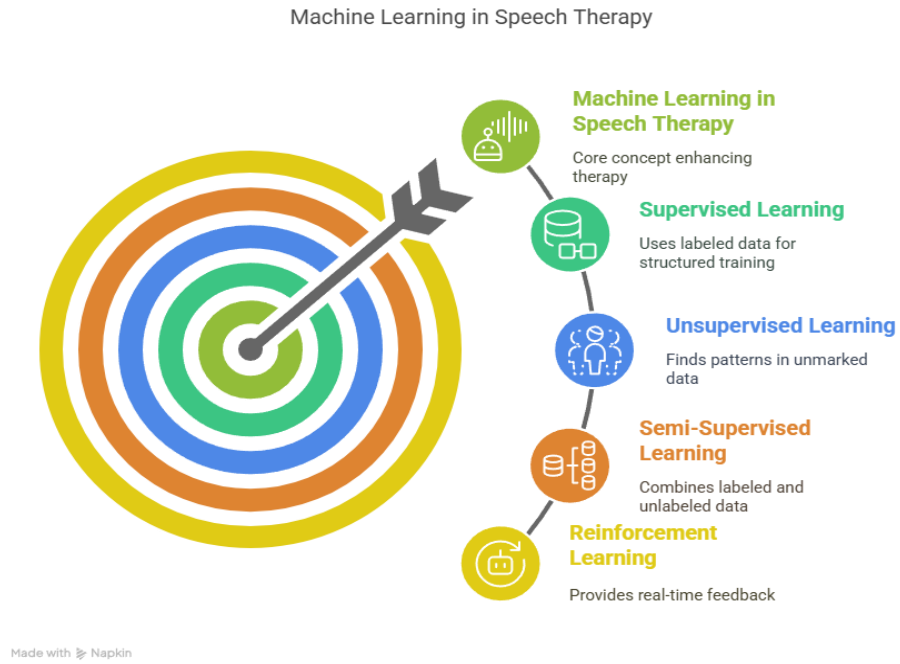


Figure II.7: Machine Learning in Speech Therapy

II.3. Advancements in AI Therapy Tools

➢ Improved AI Models Enhancing Speech Recognition Accuracy

The accuracy of AI-driven speech recognition has improved because of deep learning models trained on large, fixed datasets. These algorithms can now pick up on fine details, like subtle differences in pronunciation, that allow them to analyze speech in a way that is closer to how a human would do it. Thus, they provide feedback that is much more helpful in directing the user toward the end goal (Benway & Preston, 2024). Improvements in speech recognition also led to better comprehension assessments.

➢ Deep Learning for Personalized Language Therapy

Deep learning-powered therapy programs leverage AI to assess speech patterns and detect pronunciation errors, enabling tailored and engaging therapy sessions. By gathering real-time, user-specific data, these programs can dynamically adjust to suit individual needs, improving the speed and quality of language learning.

As described by Goodfellow et al. (2016), deep learning is a subset of machine learning that utilizes artificial neural networks modeled after the structure and functionality of the human brain. These networks, composed of multiple interconnected layers, can automatically learn and represent data hierarchically. This method has achieved remarkable success in tasks such as text creation, image recognition, and natural language translation.

- **Real-Time AI-Generated Feedback for Pronunciation Improvement**

Real-Time AI-Generated Feedback for Pronunciation Improvement AI-driven tools now generate live feedback on pronunciation and fluency, helping users rectify their mistakes on the spot and follow their improvement progress. Therapists can leverage AI analytics for trend analysis for improvement and modify therapy as necessary. This instantaneous guidance substantially quickens speech development and improves language education experiences.

II.3.1 AI Applications Across Various Fields

II.3.1.1. Healthcare:

In healthcare, Esteva et al. (2017) demonstrated that AI can analyze medical images with high precision, such as detecting cancer in its early stages, aiding doctors in treatment planning. Similarly, Mnih et al. (2015) revealed that AI can accelerate drug discovery by processing vast chemical datasets and predicting their potential effectiveness.

II.3.1.2. Education:

AI-based adaptive learning systems in education is an area in which AI algorithms analyze the student's progress and adapt the content being delivered for personalized instruction (Luckin et al., 2016). They provide real-time feedback and personal learning pathways to aid the educational outcomes. Intelligent Tutoring Systems successfully increase student performance by intelligently varying the difficulty of task depending on learner proficiency (Holmes et al., 2019).

II.3.1.3. Language Therapy:

AI is very important in Speech-language pathologies (SLP) internally by using technology like speech recognizers and external through virtual tutors. The tools provide real-time feedback and treatment plans to patients who have speech impairments. Additionally, AI systems help in reaching the language therapy more accessible and scalable which makes intervention a variable procedure for individual (Zhong, 2024).

II.3.2. Mechanisms of AI-Based Speech Recognition:

The process of extracting a human voice from sound is called speech recognition. Generally, such programs are developed by the business to allow these devices to identify Speech and works as an interface into many of the hardware. The program hears your voice or command, and responds with appropriateness. Diverse organizations develop the software that uses speech recognition based on ultra cutting-edge devices such as ai, machine learning, neural network. This includes the way people interact with hardware and electronic devices, thanks to technologies like Siri, Amazon and Google Assistant. They include smartphones, devices for home security, cars, etc (Sinha, 2023).

II.3.2.1. Steps in AI-based Speech Recognition:

According to Drozdov (2024), AI-based speech recognition involves several key steps as outlined below:

- **Microphone / Audio Input:**

The device collects your voice input as a microphone. This audio will be the input for speech recognition system.

- **Audio Signal Processing:**

Next, the recorded sound is processed into more manageable elements, often called 'features'. The features allow the system and software to make out what the sound is, such a pitch and tone.

- **Acoustic Modeling:**

Deep learning (usually neural nets) reads these features, allowing the models to recognize phonemes. Phonemes are the basic sound units of speech. Think of “s” in sun and “h” in hat are different word’s phonemes.

- **Language Modeling**:

These characteristics are analyzed by deep learning models, especially neural networks, to identify phonemes, which are the smallest units of sound. These models forecast a series of phonemes that match the words that are spoken.

- **Output Text:**

Finally, the recognized words are turned into text, which can be applied to transcription or voice command intents or for actions. For example, saying "Set timer for 10 minutes" in your command, and this command will be understood by system and timer will be set correctly.

As defined by Sinha (2023), Two closely related areas that have contributed to speech understanding and interpretation by machines are known as Speech Recognition AI and natural language processing (NLP). As opposed to speech recognition AI, which seeks to convert spoken words to digital text or commands; NLP is far broader in what it can do such as language translation, problem analysis and summarization. At the heart of NLP is to make machines able to understand and finally interpret the human language as humans do. This means not just identifying single words but understanding the context, background and meaning of these words word. How I saw a bat, for instance can have many different meanings depending on context. Meaning: some animal or a part of sports equipment.

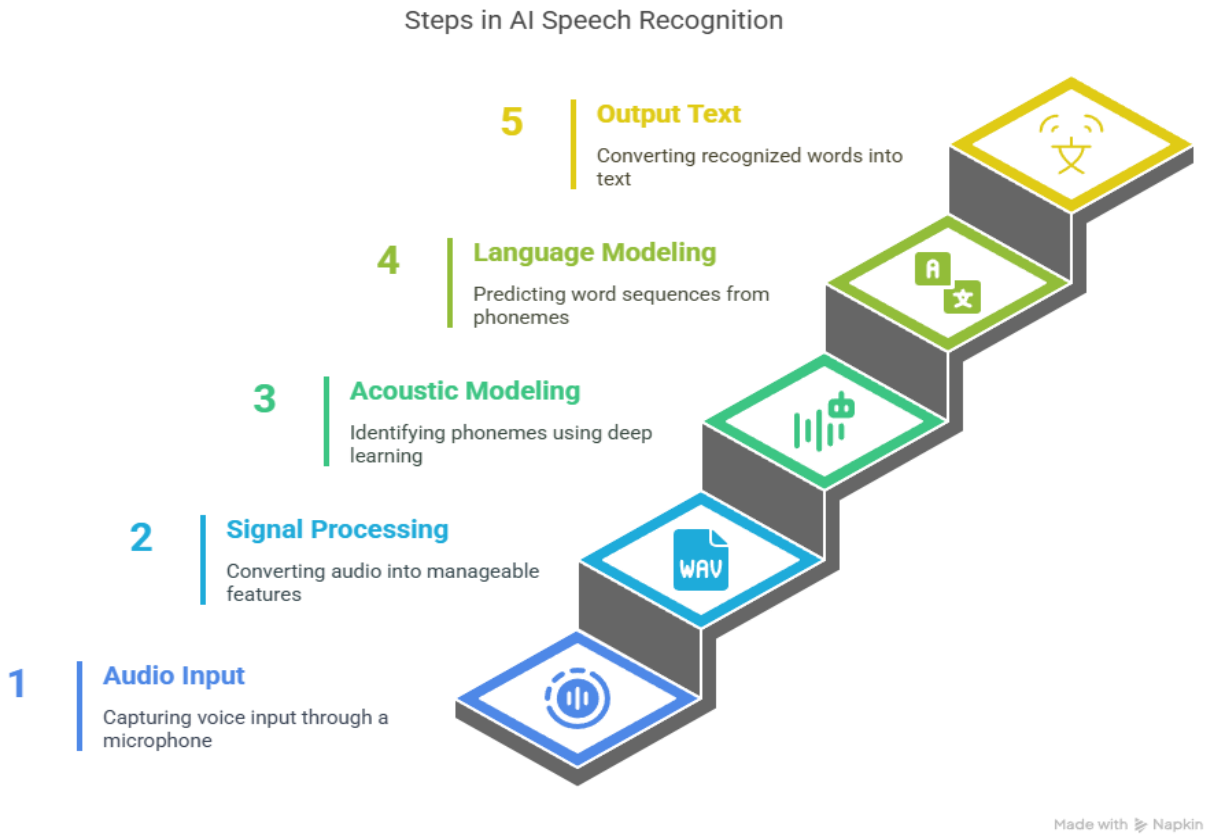


Figure II.8: Steps in AI-based Speech Recognition

II.3.3. AI-Driven Therapy Tools and Application

By using AI-driven therapy tools, one's language learning and speech therapy are much improved with personalization yet to the point of efficiency. Here are examples of the top applications in pronunciation trainer and therapy platform based on AI below:

II.3.3.1. Pronunciation Training Apps:

II.3.3.1.1. ELSA Speak:

A playful and interactive app ELSA — English Language Speech Assistant to practice in real-life conversations will make your speaking English better with the immediate feedback. ELSA's technology is artificial intelligence built using voice data of speakers of English with diverse accents. That enables ELSA to differentiate human voices as it stands apart from most other voice recognition technology. *(ELSA Speak, n.d.).*

II.3.3.1.2. Say It: English Pronunciation

Intuitive app from Oxford University Press with visual and interactive aiming to improve your pronunciation in English explaining sound wave visualizations as well as prosody markers (Oxford University Press, n.d.).

II.3.3.2. AI-Powered Digital Therapeutics:

II.3.3.2.1. Lingraphica:

It provides individuals who are non-speaking and those with speech and language impairments, speech-generating devices, and therapy applications (Lingraphica, nd.).

II.3.3.2.2. SpeechAce:

It integrates speech recognition features into language learning, with an API enabling error-free, detailed pronunciation assessments in real time. (SpeechAce, n.d.).

II.3.3.2.3. IBM Watson Speech to Text:

Transcripts audio into text by combined sophisticated ML algorithms towards a wide variety of applications that include speech therapies (IBM, n.d.).

II.3.3.3. AI-Driven Chatbots and Virtual Therapists for Language Practice

There have been remarkable advancements in artificial intelligence (AI) language learning and therapy through AI-driven chatbots, virtual therapists as sources for immersive language practice that is easily accessible. AI-driven tools like NLP, speech recognition and Machine

Learning in real-time conversations imitates a human-like way of speaking and provide feedback on pronunciation, grammar, fluency.

II.3.3.3.1. Applications of AI-Driven Chatbots and Virtual Therapists

- **Conversations as Personalized Practice**

Duolingo adaptive AI tutor and ChatGPT-based language bots enable users actual-life conversation where the learner give consistent and customized responses for their level of proficiency (Seizt, 2024). In other words, the chatbots corrects grammatical mistakes, tells you alternative phrases and gives immediate feedback to increase fluency.

- **Speech Therapy for Language Disorders**

AI-based speech therapy programs like Tactus Therapy and TalkPath Therapy are valuable because they contain speech recognition technology that assists aphasia, apraxia, and dysarthria patients assess and boost their speaking mechanisms (Kurland et al., 2018). Voiceitt is another tool that helps aphasia patients change their speaking habits and communicate more effectively.

- **Pronunciation and Accent Correcting**

AI-driven pronunciation training tools, such as ELSA Speak, and SpeechAce, utilize real-time phoneme-level voice analysis (Nguyen & Tuyen, 2024). These apps deliver immediate feedback, enabling users to enhance their pronunciation and refine their accents efficiently.

- **AI Language Therapy Assistants for Children**

AI-Supported Language Therapy for Kids Milo the Robot and KidSense AI are AI-fueled virtual coaches that help speech-delayed or autism spectrum disorder (ASD) kids with structured language workouts and communication skills, conventional tactics. Language learning becomes all the more fun and interactive with them, as they offer gamified classes and workouts for the children (Teixeira & Lai, 2021).

- **AI Chatbots Translated in multilingual for learning**

Chatbots powered by AI, like Mondly and HelloTalk AI, allow users to have authentic conversations in various languages, facilitating language practice for purposes such as travel, work, or everyday life. These chatbots offer context-sensitive corrections and tailored learning experiences, improving language learning through engaging dialogue (Petrović & Jovanović, 2021).

- **Challenges and Open Problems**

While the advantages of AI chatbots and virtual therapists cannot be undermined, challenges are still present mostly due to emotional intelligence and limited adaptive AI. Current AI systems are terrible at empathy, recognizing emotion and are far away in replicating all subtle nuanced human interactions required for good therapy. Deep learning and the improvement of emotion recognition may advance future development in personalized, AI-driven speech therapy tools.

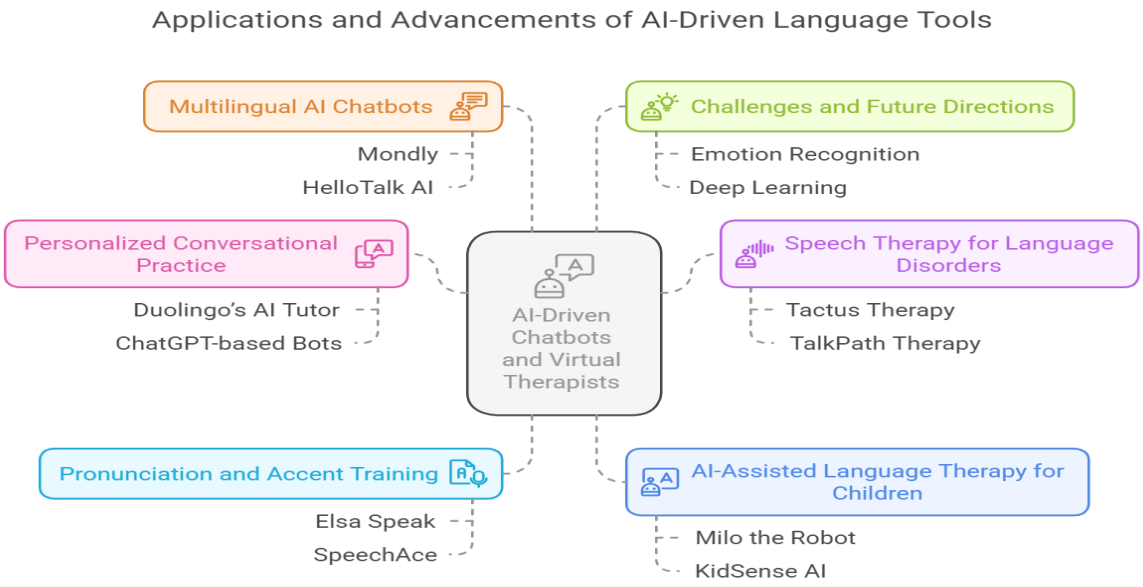


Figure II.9: Applications and Advancements of AI-Driven Language Tools

II.4. Benefits and Challenges of AI in Speech Therapy:

II.4.1. Benefits:

II.4.1.1. Immediate Feedback for Pronunciation and Fluency:

Real-time feedback on pronunciation and fluency: AI speech recognition systems can analyse speech in real time and give user instant feedback relative to their pronunciation and fluency. This instantaneous answer allows for quicker error correction and impresses the learning, especially in phonetic training.

II.4.1.2. Personalized therapy plans:

One of the main benefits of AI in speech therapy is that it helps to personalize activities. Specific goals can then be identified based on speech samples from a child, with AI algorithms assessing those speaking patterns and creating exercise designed for each feature challenge. An individualized approach facilitates better therapy results more economical and fruitful. (Clinic Source, n.d.)

II.4.1.3. Enhanced Engagement:

AI can provide data-driven insights for speech pathologists to re-evaluate and modify treatment as needed. By analyzing large sets of data, AI can predict client outcomes and fine-tune intervention strategies, making therapy more effective (Zbrog, 2023). To make the process enjoyable, many of these interventions are gamified, allowing clients to engage with therapy in a fun way. With elements of play and competition, apps and digital tools motivate patients to practice more frequently and consistently. These interactive features not only keep patients interested but also encourage them to actively participate in their therapy sessions, making the experience feel more personal and engaging. (MySpeechSpace, 2025)

II.4.2. Challenges:

II.4.2.1. Accuracy issues:

For an SRS, delivering an advantage means obtaining high accuracy, but this remains inherently challenging, especially due to the need for compatibility with diverse languages, accents, and dialects. With more than 7,000 spoken languages globally, all filled with innumerous regional accents and dialects- English alone accounts for more than 160 dialects worldwide. No SRS covers all variations of language exhaustively. Even to extend support to just a handful of the most widely spoken languages would bring ever so many technical and logistical challenges (Dilmegani, 2025).

II.4.2.2. Dependence on AI vs. Human Therapists:

Although AI is a helpful resource within therapy, it needs to be used in moderation and with technology aiding not replacing interaction from a human. Empathy and connectedness are the foundation of successful therapeutic working and overuse AI can minimize these core parts.

Dependence on AI might hinder the human contact central to therapy, weakening the quality and depth of the therapeutic process (Khera, Simon, & Ross, 2023).

II.5. Ethical and Practical Considerations:

II.5.1. Data Privacy and Security in AI-Based Tools:

Since the data collected by AI based health care systems are some of the intimate client information, it is imperative that privacy and security are given highest priority. Integrating AI with speech therapy process must entail clients informed consent, need for storing data securely and must be in an ethical manner to secure client records. Therapists can use these guidelines for the security and privacy of their clients' speech data under the cover of AI (Williamson & Prybutok, 2024).

In order to secure patient data in healthcare artificial intelligence, ensure that the tools you choose comply with the standards set by the Health Insurance Portability and Accountability Act (HIPAA). Client data needs to be encrypted in transit and at rest to protect against unauthorized access. Multi-factor authentication (MFA) serves as an extra line of defense by not allowing access to confidential information with just a username and password. AI tools security audits are essential, since these audits can conduct regular security check of how protected the tools are and deal for any possible weakness (Mayover, 2024).

II.5.2. Accessibility and Financial Barriers:

II.5.2.1. High Costs of AI-Driven Therapy Tools:

Speech therapy technology can be expensive, especially with membership-access payment plans, making it hard for those without substantial incomes to afford it. The costs of AI speech therapy can also lead to monetary challenges, which might restrict practitioners' and patients' use. Moreover, variations in functionality and branding across different app stores could lead to customer confusion when seeking a consistent experience (Bhardwaj et al., 2024).

II.5.2.2. AI Improving Access for Remote Users:

AI-dependent speech therapy intended for users in the remote who cannot access an in-person therapist. These users might have issues like bad connectivity, ignorance regarding digitalization and limited availability of the advanced technology which could degrade the quality of AI based therapy delivery.

II.5.3. Bias in AI Models:

II.5.3.1. Challenges in Understanding Dialectal and Accent Variations:

As there are over 7000 planet-wide, and probably even millions of accents/dialects (e.g., over 160 English variants1) AI speech recognition systems can never hope to provide a comprehensive representation of all these varied speech forms. What stems from this, is structural bias that limits marginalized groups (e.g., non-native speakers, people of color) from having a just share in AI-powered healthcare or education tools (Ajanaku, 2022). Closing these divides will require more diverse training data, improved algorithms for fairness and scalable solutions that align AI developers with clinicians & ethicists to support solutions that put the patient first, such as speech therapy.

To address these biases, it is necessary to build diverse datasets that integrate various speech patterns, accents, and dialects. Diverse speech datasets permit AI models to recognize and adapt to different linguistic variations. This makes a model perform better and cater to different groups of individuals. One solution is the Speech Accessibility Project's collection of speech samples from volunteers in order to create a wide-ranging dataset for machine learning models (Beckman Institute, n.d.).

II.6. Collaboration and integration with traditional therapy approaches:

AI insight integration and evidence-based practice (EPG) guidelines are in the speech therapy meaning that clinicians will be able to make truly evidence informed decisions because AI system can find patterns and likelihoods of therapeutic technique outputs in big datasets so that therapists can personalize treatment using AI insights within an established protocol. The combination of clinical judgment with AI outputs, in synthesizing select AI tools to amplify rather than eradicate human judgment, maximizes client outcomes and advances therapeutic practice for

the provision of client-centered care in an ethical manner. It centers on the cross-disciplinary work in therapy, healthcare professional, research and technologists together to generate state of the art care models, reduce biases and maintain a quality service that is scalable, equitable solutions which strikes a balance between technological efficiency and the unparalleled richness of human experience (Green, 2024).

Conclusion

Technology and AI are reshaping the language therapy field to a much bigger level, transforming interventions in real time at scale with high precision. AI Administrator new understanding of analysis and feedback on speech recognition, along with real-time training have changed a big chunk of new pronunciation training so that it is possible to accurately record therapist and patients' development. All of this is in the favor of a more individualized therapy than ever before; reduced dependence on direct intervention and hence such an intervention can be scaled across a large population with speech & language disorders.

AI Applications: Applications which will make therapy more engaging and accessible for the person, by increasing access to therapy for those with limited access to professional help through the means of applications such as automated speech assessment tools or interactive virtual assistants.

The positives of this are, however have to be balanced against the fact data privacy, ethical questions and bias in AI training sets are challenging. The NLP and deep learning models are failing at picking up the complexities of human language, which are necessary for language therapy. The first prosody and emotional tone, contextual semantics etc. These tools enable work but must always function as an aid to human therapist providing primacy to the emotional and cognitive aspects of therapy.

Moving forward in time AI might be more obsessively involved to increase language therapy. There are some upcoming in the frontier of deep learning and natural language processing to increase the performance of speech recognition across different linguistic background, not talent on other impediment also. The future of predictive analytics powered AI therapeutic devices that learn how your assist during each session enables the interventions to become much more agile and adaptive based on how individual patient went. Moreover, they may lay the foundation of

applying AI directly with wearable devices, brain-computer interfaces and augmented reality devices for people who are effectively non-verbal and have profound speech impediments.

To ensure that AI can make its positive, essential contribution to the drive of language therapy, it is essential that we develop Ethical AI development making it possible by creating an Emergent Allow framework supporting Dataset diversity in AI tool development as well as efficacy should be treated as supportive instead of an agent mechanism which will replace for professional therapist. Main agents of this effort will be AI developers, linguists and speech therapists to get the appropriate technologies fine-tuned and effective. After all these hurdles, an intelligent enactment of AI will enable technology to reimagine language therapy for all people with speech and language disorders.

CHAPTER THREE: Methodology, Data Analysis and Interpretation

Introduction

The preceding chapters gave an overview of AI and its use in language therapy, such as speech analysis and recognition. In this chapter, the methodology adopted to investigate the use of technology and AI in language therapy, with a leaning towards pronunciation training as well as instant feedback to clients, is outlined. Since AI-based tools like language learning programs are gaining immense popularity in speech therapy, there is a need to analyze their efficacy, pros, and cons. This chapter offers a summary of research design, data collection methods, analysis methods, ethics, and the way this study addresses our problems of research.

III.1. Research Design:

The initial inquiry technique is a survey administered on 95 randomly selected people in order to gather their awareness and perception about the use of AI in speech therapy. The survey is designed in order to yield quantitative information based on opinions in terms of what role, efficacy, and boundary AI has towards speech therapy.

The second research methodology is a case study that identifies how AI plays an active role in supporting speech therapy. The case study shall be based on real-world contexts, analyzing how AI-based software affects people suffering from speech disorders. Through a study of some specific cases in which AI assisted in improving speech, the research will offer intensive insights into its real-world applications and challenges. This dual approach enables both statistical and qualitative comprehension of the effectiveness of AI in speech therapy.

III.1.1. Questionnaire

III.1.1.1. Sample:

The sample for this study is 95 participants, selected with careful consideration to attain maximum diversity of gender, age, and professional status. Participants vary in age from young adulthood to middle age to older age and across a broad range of careers, including education, health, business, and technical professions. The diverse sample permits a more rigorous test of the results of the study across a variety of demographic and professional contexts.

III.1.1.2. Aim:

Questionnaires are now the mainstay of research design, and an efficient means of gathering lots of data in a short space of time. Questionnaires are "written instruments which pose questions or statements to respondents to which they are asked to react either by writing down the replies or by choosing from amongst available alternatives" (Dörnyei and Taguchi, 2009).

Anderson (1998) points to their effectiveness in collecting valid and reliable information. Questionnaires consisting of a set of questions are most commonly made up of and are widely used due to their many benefits: they save participants and researchers time and money. Through the postal system, researchers can send questionnaires to a population of interest and collect huge amounts of information within a brief period, say an hour.

Carefully prepared questionnaires, particularly with the aid of computer programs used in statistics, can be processed with ease and speedily. According to Beiske (2003), they offer several advantages: they are intuitive and easy for most individuals to complete, reduce the likelihood of researcher bias affecting responses, allow participants the flexibility to complete them at their convenience, and streamline the data analysis process.

III.1.1.3. Design:

According to Hotjar (2023), the ideal questionnaires use closed as well as open questions to provide breadth as well as depth in data collected. Hence, while designing the questionnaire, we have used a mix of types of questions to overcome its drawbacks. Closed questions, which have pre-coded answers such as "Yes/No", are quick and easier to answer but can limit the degree of responses. Designing such questions should be done carefully so that they can gather information as needed. In contrast, open questions give respondents room to offer answers in their own words, they give more descriptive and comprehensive information, yet harder to analyze and to categorize.

III.1.1.4. Piloting:

Pilot study is one step towards guaranteeing the efficacy of a questionnaire. Cohen, Manion, and Morrison (2002) highlight that "a pilot has several functions, principally to increase the reliability, validity, and practicability of the questionnaire" (p. 260). Wallace (1998) also highlights

the significance of the step, mentioning that piloting enables researchers to make their questionnaire better in terms of clarity, relevance, and efficiency in collecting data (p. 133).

The major purpose of piloting is ensuring that the questionnaire functions as required, even when tested on a limited number of respondents. For this purpose, the research followed some rules:

• Are instructions clear and comprehensible for following?

• Are the questions simple and relevant to the research question?

• How much time is required to fill in the questionnaire?

Piloting is also used to pinpoint possible issues, e.g., ambiguous questions, inappropriate-ate questions, or excessively high completion rates, with necessary changes before actual use. In the view of Wallace (1998), this helps to make the questionnaire reliable, valid, and pragmatic in its capacity to confirm its effectiveness in generating meaningful information (p. 132).

III.1.1.5. Introduction to the questionnaire:

In order to better understand how people from different backgrounds think and use AI in language therapy, we developed an in-depth questionnaire of 18 questions. Our questionnaire is designed to be both interesting and revealing and includes a combination of 16 closed questions with definitive answers and 2 open questions for participants to discuss at length their views, experiences, and concerns about AI-based tools in language therapy.

III.2. Analysis and Interpretation:

III.2.1. Analysis of the Questionnaire:

Part 1: Demographic Characteristics of Participants

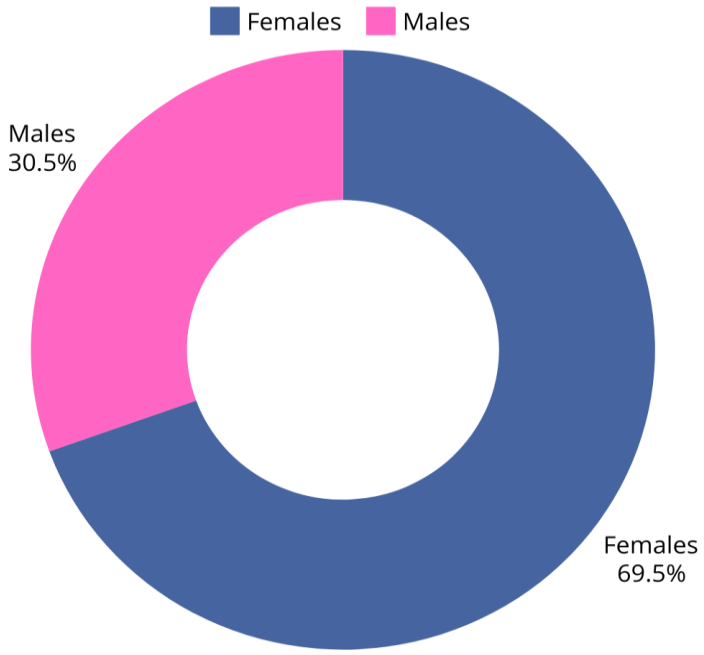
Item1: Participants' Gender

The statistical information shows an unequal gender split among the 95 participants, whose gender distribution was 69.5% (n=66) who were female and 30.5% (n=29) who were male. This shows an overwhelming dominance of females among participants and can be seen to represent overall gender trends in speech therapy practice, in which females typically represent the majority of practitioner and student numbers.

Various factors can account for this gender disparity, among them sociocultural norms, occupational preference, and structural trends in healthcare and education. In addition, the perception of speech therapy as a caregiver's profession, one which historically has been pursued by women, can contribute to an oversampling of females.

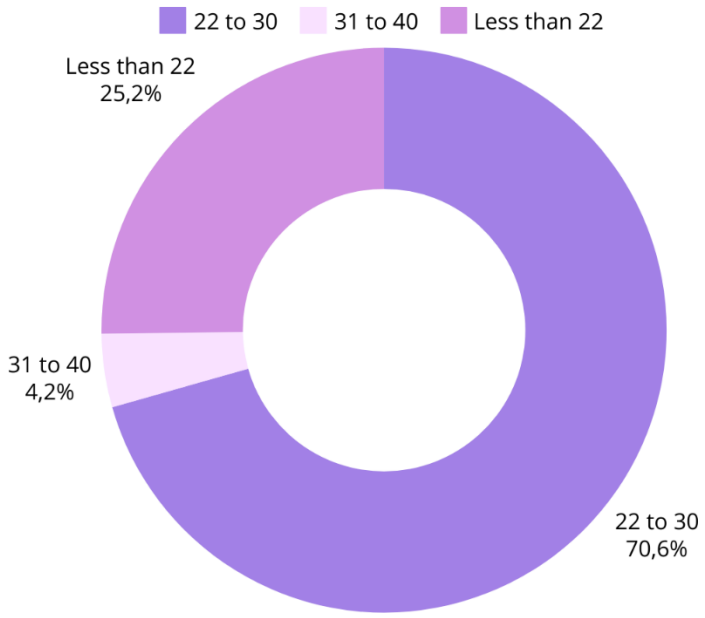
This gender balance can have implications for attitudes towards and use of AI tools in speech therapy. Attitudes towards technology, professional training backgrounds, and ethical considerations can differ depending on gender balance within the profession. Identifying these trends can assist in developing AI-based solutions to address different needs of speech therapy patients and professionals.

Further investigation of whether this gender split is characteristic of the wider speech therapy profession or specific to this research's sampling could give greater insight into workforce trends. Looking at gendered viewpoints on AI uptake in speech therapy can also assist in developing more inclusive and impactful AI-based therapeutic intervention.



Item 2: Participants' Age

This question aims to know the age of each participant



The age profile of respondents who use AI in speech therapy is diverse in terms of profession. Under 22-year-olds, mostly students and new professionals, comprise 25.2%, while 70.6% of respondents aged 22–30 demonstrate high interest among young professionals from various professions. 4.2% of respondents aged 31–40 consist of experienced mid-career professionals who examine the integration of AI in practice. Such diversity represents collaboration potential of speech therapists, teachers, AI engineers, and healthcare professionals who can further enhance AI-based therapy solutions. Different age profiles and professions should share insights from each other's multidisciplinary views in order to apply AI in an effective manner in therapy, education, and healthcare practice.

Item 03: What is your occupation?

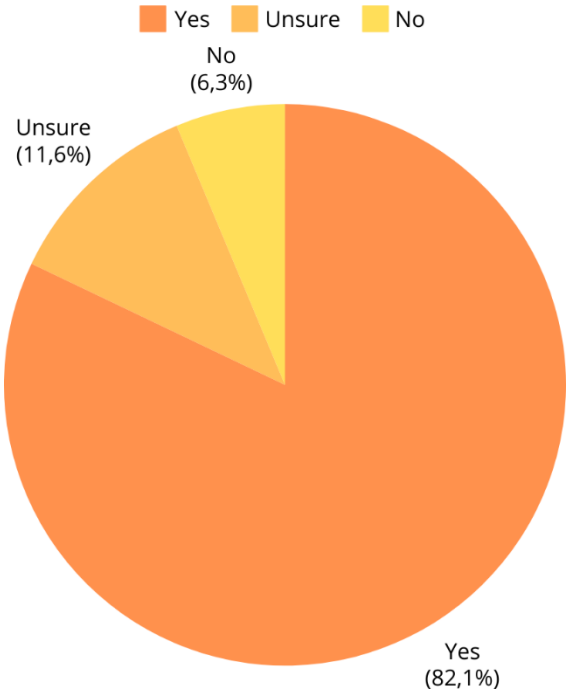
The purpose of posing this question is to acquire knowledge of the respondent's professional history and area of specialty. This allows one to understand how career paths contribute to views concerning AI in speech therapy and applications in different domains.

The respondents have diverse occupation backgrounds ranging from individuals involved in business and e-business, in medical and healthcare professions such as nurses and medical students, educationists, and students. Some of them might even be connected to sports (football), entertainment (video games), or possibly even unemployed at this point in time. Due to this diverse occupational pool, diverse opinions pertaining to AI speech therapy are collected which reflect experiences from technical and nontechnical backgrounds.

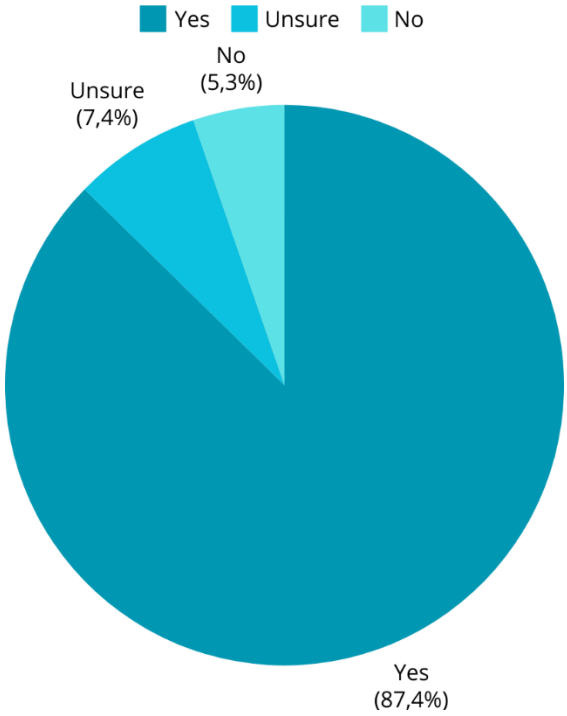
Part 2 : Questionnaire Structure and Response Types

Question 1: Do you believe technology provides unique benefits that cannot be achieved through traditional language therapy methods?

The study revealed 82.1% (n=78) of participants attesting to technology having apparent benefits over standard language therapy, including instant corrective feedback, tailored learning experiences, and convenience of accessibility. The results confirm the general positive stance towards AI-based software and computer-mediated interventions in therapy. However, 6.3% (n=6) were concerned with validity, reduced human contact, and ethics, and 11.6% (n=11) were neutral, observing more research and hands-on use by the implementation of AI. The use of technology in speech therapy is more and more acceptable, but AI is viewed mostly as an expansion of the traditional procedure.



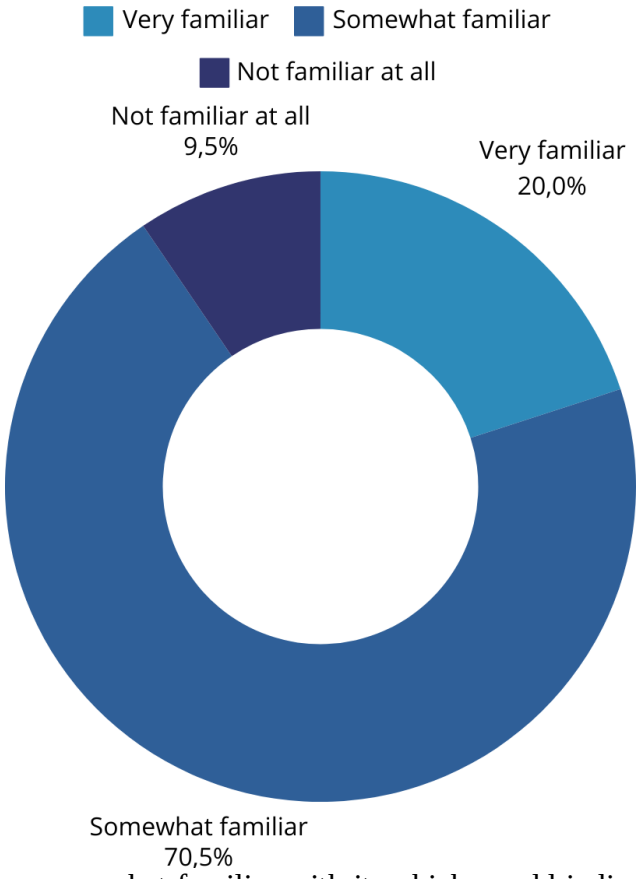
Question 2: Do you think technology-based tools encourage independence in language learning for clients?



The results show that a vast majority of respondents (87.4%, n=83) believe that technology-based tools foster independence in language learning in clients. This shows strong confidence in AI-driven tools and online platforms, most likely due to factors such as self-paced learning, instant feedback, and interactive exercises facilitating clients to learn on their own without the need for continuous therapist supervision. A minority (5.3%, n=5) disagreed, possibly due to reservations about over-reliance on technology, lack of human interaction, or the need for therapist guidance. Meanwhile, 7.4% (n=7) were undecided, indicating some equivocation about the capacity of such tools to induce autonomy. Overall, these findings highlight the perceived potential of technology to enable clients to be more in charge of their language learning process while at the same time indicating the need for judicious complementarity with traditional approaches to therapy.

Question 3: How familiar are you with the use of technology in language therapy?

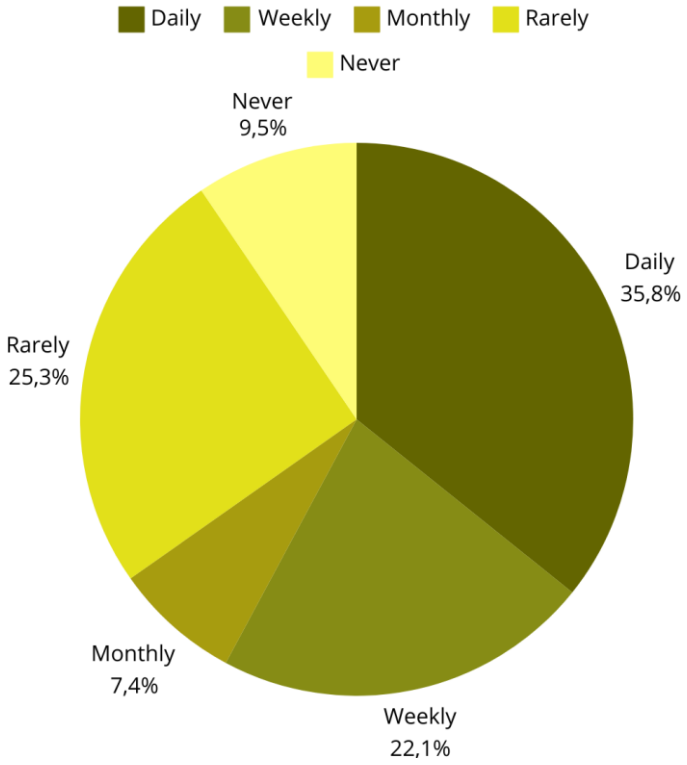
The data indicates that most of the respondents at least know of technology in language



therapy. 70.5% (n=67) are somewhat familiar with it, which would indicate that while they may know the basics or have experience with it, possibly they are not yet proficient in the use of these tools. 20% (n=19) are very familiar, which would indicate a lower subgroup with high levels of experience, possibly through professional use or direct use of AI-based therapy tools. 9.5% (n=9) are not at all familiar with it, which would indicate a lack of awareness or exposure to technology in this field. These findings would indicate that while technology is increasingly recognized within language therapy, its effective use is still in need of awareness and training programs.

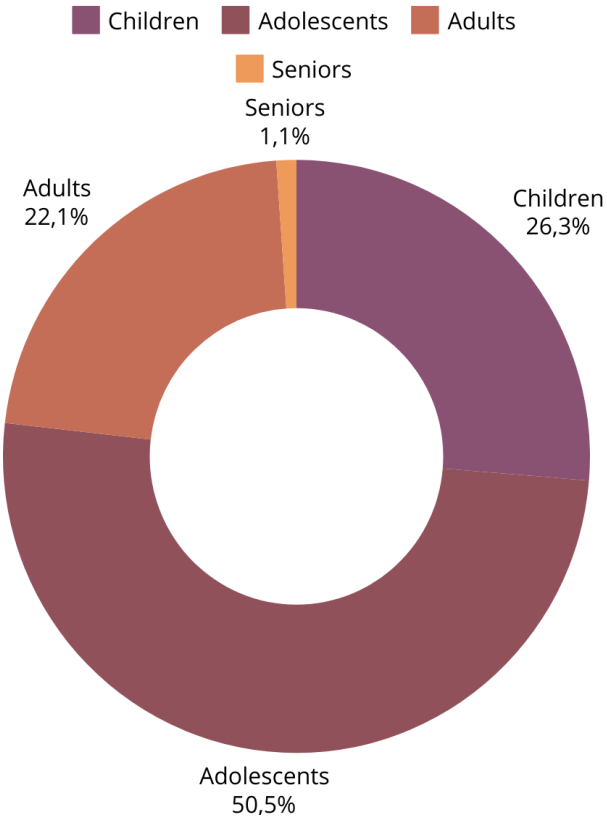
Question 4: How often do you use technology (apps, software, etc.) as part of your language therapy sessions?

The results indicate the frequency of technology use on different scales in language therapy. 35.8% (n=34) of the respondents use technology daily, indicating high rates of digital tool use in their practice, perhaps for real-time feedback, interactive tasks, and AI-based testing. 22.1% (n=21) use it weekly, indicating moderate usage, perhaps to augment traditional approaches. 7.4% (n=7) use it monthly, indicating occasional usage, perhaps to apply it to specific cases or research. 25.3% (n=24) of the respondents use technology rarely, and 9.5% (n=9) never use it, indicating reluctance or unavailability. These findings suggest that technology is well-liked but that training, availability, or skepticism may still limit its everyday use in language therapy.



Question 5: What age group do you think benefits the most from technology-assisted language therapy?

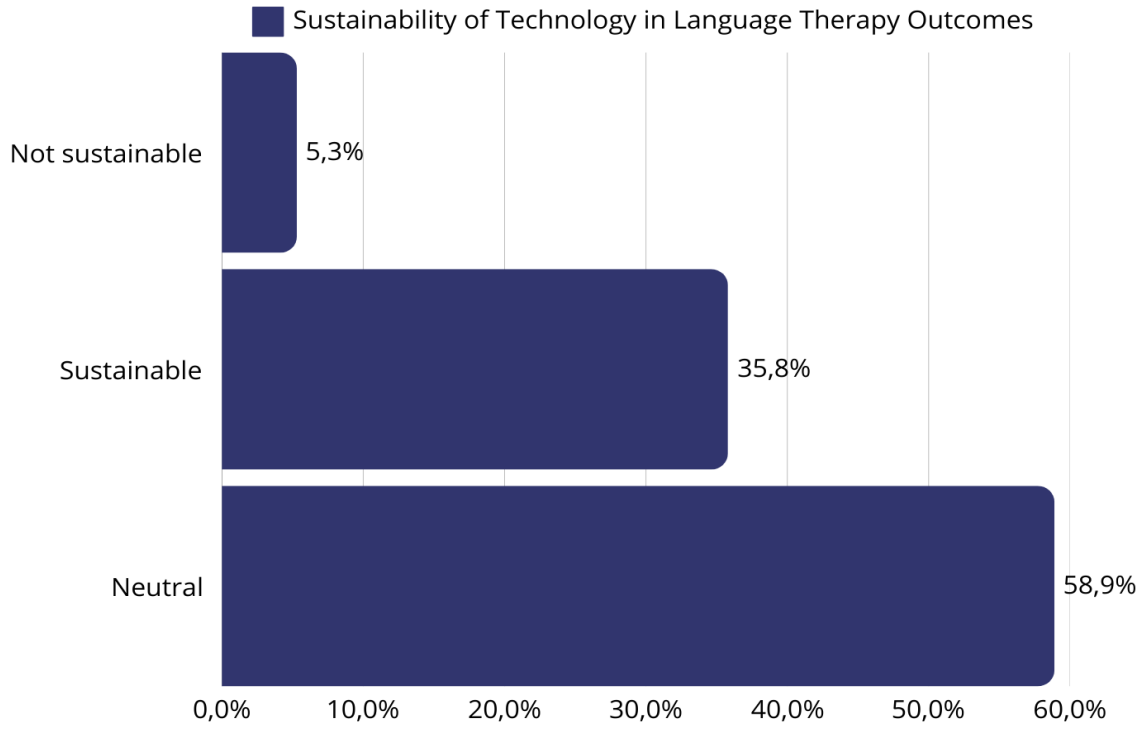
The majority of the respondents (50.5%) assume that teenagers benefit the most with technology-based language therapy. This may be because teenagers are more at ease using digital tools and more interested in their use of technology in everyday tasks. Children also benefit a lot (26.3%), possibly because the interactive and fun aspect of technology-based therapy is favoured by children. Fewer of them identified adults (22.1%) or elderly (1.1%) as recipients, perhaps reflecting lower technical competence or varying therapy needs among those groups.



Question 6: How sustainable do you think the use of technology is for long-term language therapy outcomes?

The results show that the largest proportion of respondents (58.9%) are neutral in their opinion of the long-term sustainability of technology in language therapy, with doubt as to its long-

term efficacy. 35.8% believe it is sustainable, with trust in AI-based tools and digital resources to facilitate continued therapeutic improvement. 5.3% believe it is not sustainable, possibly because of concern over ease of access, over-reliance on technology, or the need for human contact in therapy. These results suggest the need for further studies and practical evaluations to determine the place of technology in delivering long-term language therapy results.



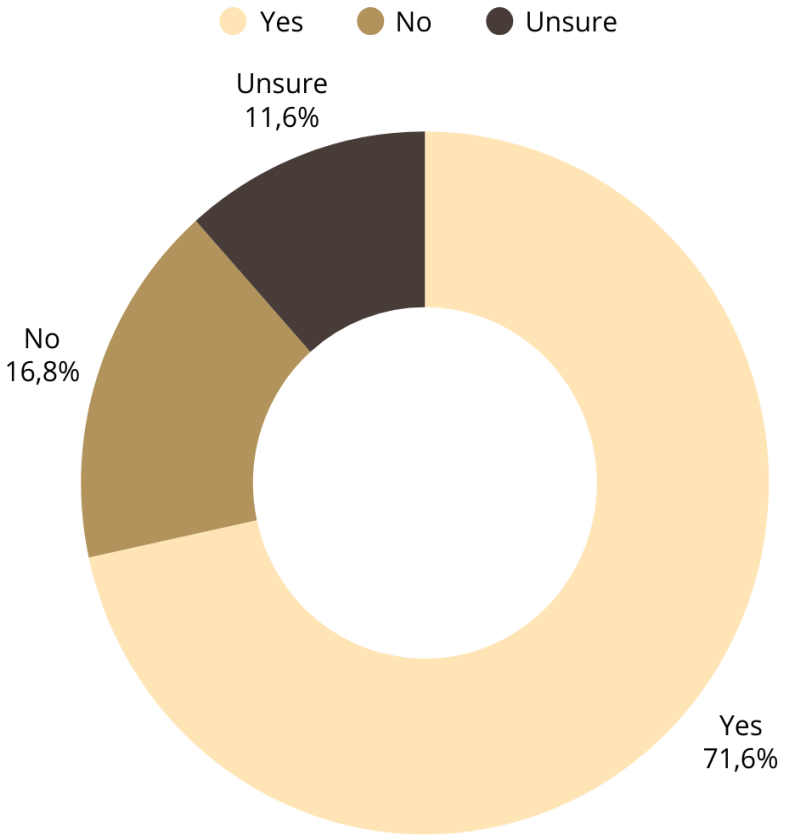
Question 7: What factors influence your decision to adopt a particular tool or app for language therapy? (e.g., cost, user reviews, features, etc.)

An analysis of the 74 responses presents some clear trends with respect to how technology is selected within language therapy. Cost becomes a legitimate concern here, many reiterating their needs for customer pay, subscription, and free trial. User reviews are extremely important, as many professionals will look to other experts or clients before jumping on board a tool. Mostly customization, progress tracking and interaction are brought the features as well as easy to use to generalize accessibility for both therapist and client. Others point to effectiveness validated through research or by way of clinical effectiveness. And also, the need for compatibility and accessibility (an app should can be used with any device and respond for a variety of clients) are also noted. Privacy and security used to be another issue for people who hold the client data

confidential. Even according to the responses, picking of a language therapy tool is a trade-off between affordability, effectiveness, usability and client engagement to produce desired outcomes.

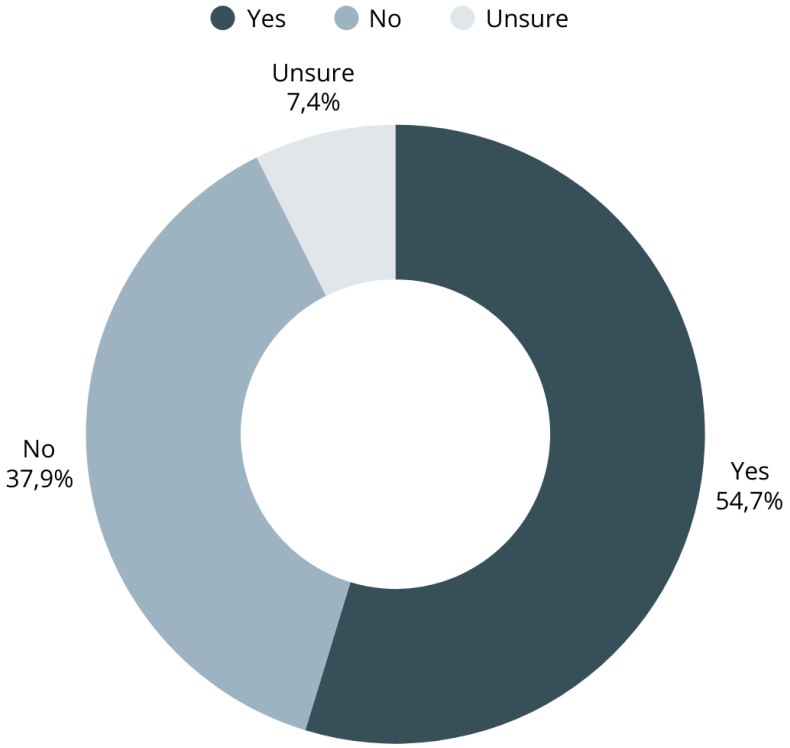
Question 8: Are you aware of the role of artificial intelligence (Al) in language therapy?

Results of the survey show that majority (71.6%, n=68) of respondents could identify AI and its place in language therapy, meaning AI is becoming more recognized as a potential tool. Or it could just be because everyone uses AI in what we do: example of a speech recognition software, virtual assistants and automated feedback systems. And 16.8 % (n=16) are not aware of it, which tells us a knowledge void that should be clearly dictating an educational or professional pathway. Further, the 11.6% (n=11) that are uncertain show that while exposure is possible, people may not know how AI can or should be used in language therapy. This implies that more awareness drives and training that makes accessible information useful for both the professionals and users are necessary in relation to the development and application of AI for language therapy.



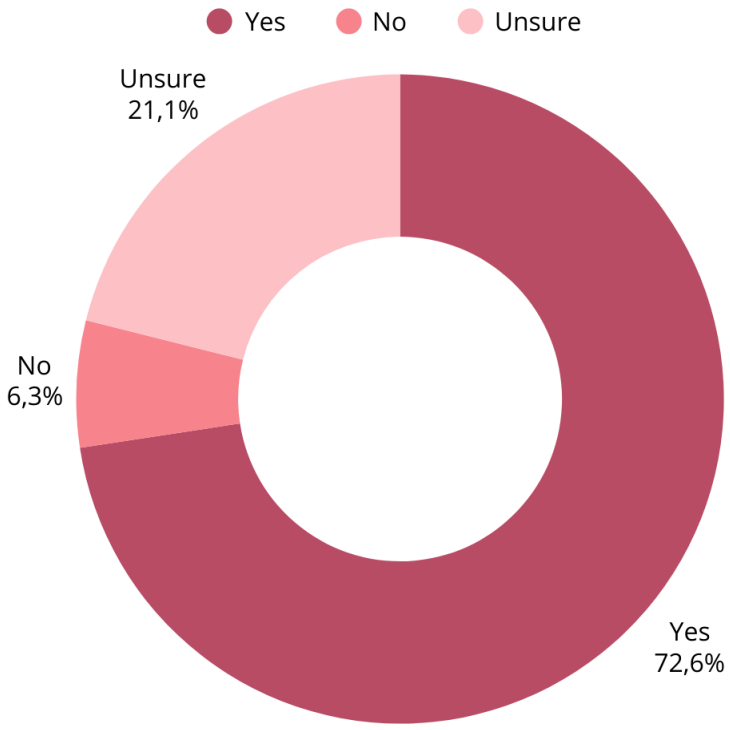
Question 9: Have you used any Al-based technology or software tools in language therapy?

With 54.7% (n=52), AI embedded technology or software tools within language therapy have become widespread, and use of AI in practice is growing. However, 37.9% (n=36) have not utilized such types of tools which may reflect logistical problems surrounding availability, contextual, or training. In addition, 7.4% (n=7) are those who are undecided whose query suggests ambiguity surrounding whether those tools they use include AI. These data highlight the growing use of AI in language therapy as well as an obviously expressed need for further training and availability for extended use.



Question 10: Do you feel that using Al tools for language therapy accelerates the learning process?

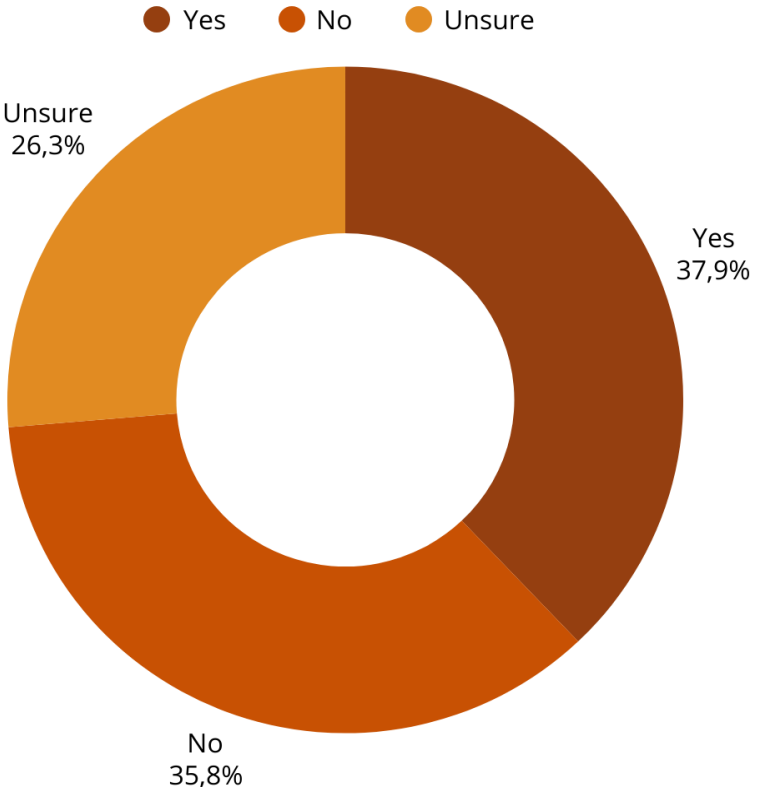
The results showed that nearly all participants (72.6%, n=69) agree in their view that AI devices quicken language learning, showing support for AI efficacy in terms of power-saving and motivating therapy. A low percentage (6.3%, n=6) is against it, possibly due to an assumed lack of clarity of understanding of what AI can do in comparison to traditional practice. And 21.1% (n=20) do not know, seemingly due to insufficient knowledge about AI uses or expressing doubtful concerns about its use in the future. These data results demonstrate overall positive opinions about AI for language therapy yet some points of further research and education.



Question 11: Have you encountered any challenges while using Al tools for language therapy?

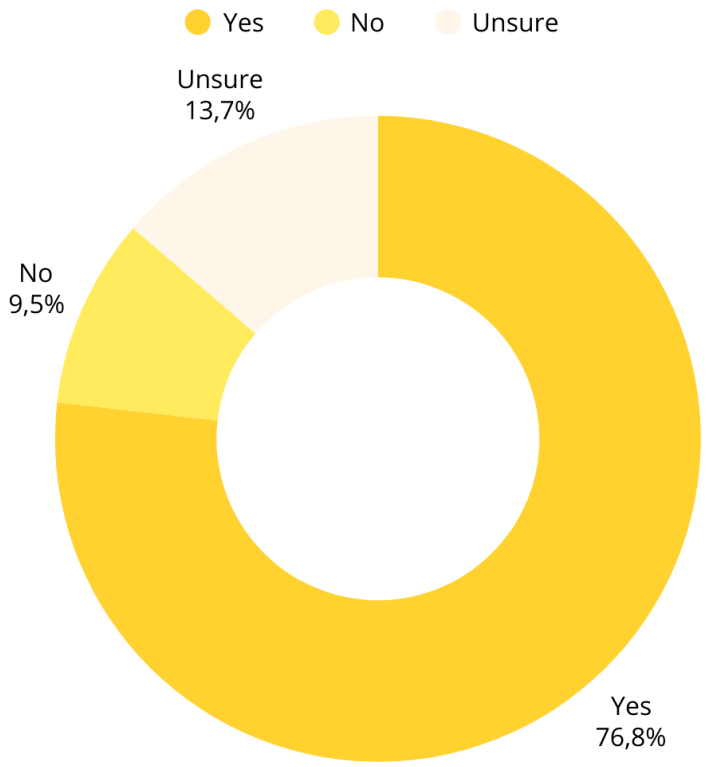
These results point out that as much as 37.9% (N=36) of the respondents have at one time or another faced any problems with AI tools and language therapy showing that although the technology has a lot in favour, problems like technical issues, inaccuracies or adaptation difficulties may be associated to it also. Meanwhile, 35.8% (N=34) showed zero challenges however per figure it seems AI tools for many end users behave very well. But still, 26.3% (N=

25) are clueless which might mean either minimal exposure to AI tools and disinformation about the issues. These findings suggest that while AI is a promising addition to language therapy, the usability must be resolved and proper training promoted to get wide acceptance and service.



Question 12: Do you believe Al and technology should be integrated more into language therapy practice?

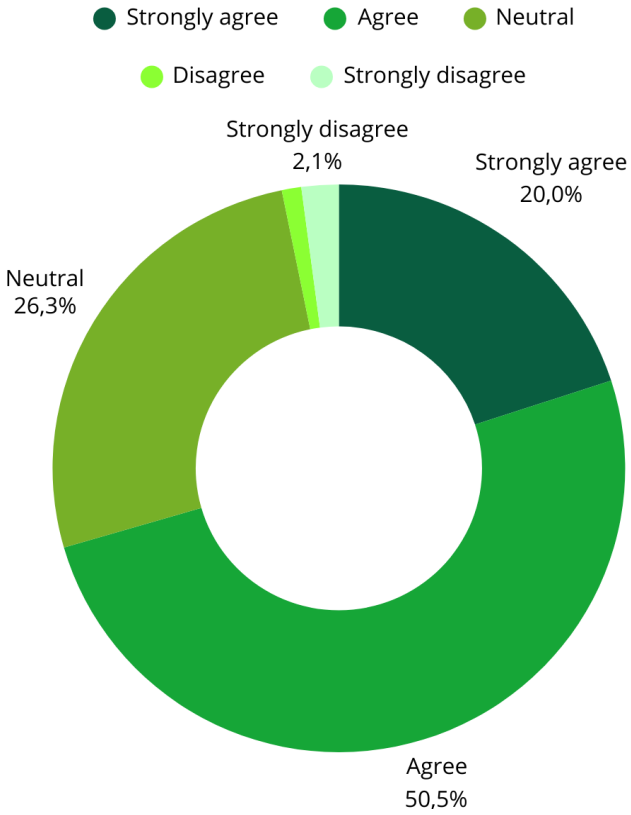
A high percentage of respondents (76.8%, N=73), majority support for AI and technology being incorporated into the practice of language therapy, as shown by the majority In a minority, (9.5%, n=9) the respondents said that they do not support further integration as they were concerned with effectiveness, dependency or ethical considerations. Next 13.7% (N=13) were at fence sitting borders indicating that we need more knowledge, research or tried experience working with AI driving language therapy tools. The findings demonstrate increasing acceptance of technology in the field however also reveal the need to address scepticism and that AI should be an addition, not a replacement for traditional therapy practices.



Question 13: Al and technology improve both specific skills (e.g., pronunciation) and overall therapy outcomes.

Most of the respondents (70.5%, N=67) either agree or strongly agree AI and technology increase (e.g., pronunciation) skills, and enhance outcomes overall in speech therapy. It indicates the general acknowledgment of these tool's advantages within language therapy with focus on increased purpose language skills. A considerable number of posters (26.3%, N=25) lie in the camp of "neutral", some have little experience with AI-based therapy tools or perhaps are just not sold on their long-term efficacy. A tiny minority (3.2%, N=3) disagree or strongly disagree perhaps because of perceived limitations, effectiveness, or other shortcomings of AI. These results

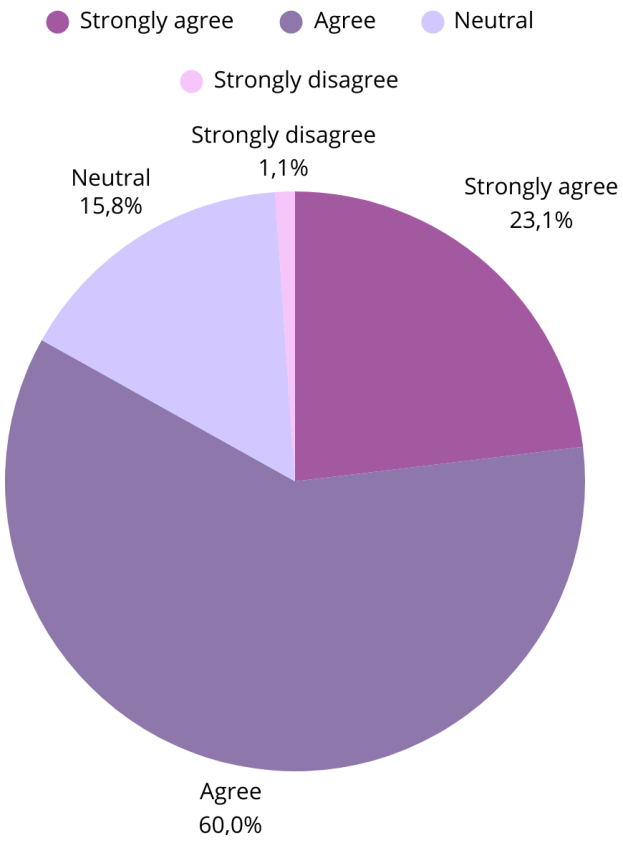
highlight a generally positive perception of AI's role in language therapy while pointing to areas where further evidence or training may be needed to convince skeptics.



Question 14: Therapists need more training to effectively use technology in language therapy.

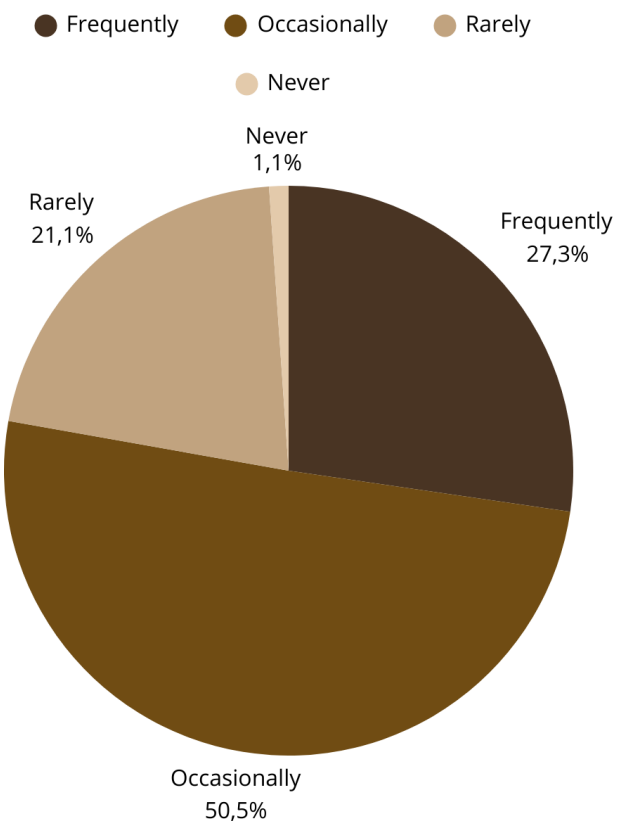
A very high percentage of respondents (83.1%, N=79) either concur or strongly concur that therapists need more training for technology in language therapy to be used effectively. It indicates that although AI and other tech tools used in therapy are increasing, many of the professionals may not possess the required competences or because of that, they do not trust on the benefits. 15.8% (N=15) opted-neutral, ambiguous as to wonder if there are training gaps there or have trainers is already doing its work. Only 1.1% (N=1) strongly disagree, I think one person is a very small

sample size in regards of not needing more training. This result emphasises the need for therapist training to improve so that technology can be effectively utilised in practice.



Question 15: How often do you feel AI-based tools fail to recognize speech correctly due to accent, dialect, or speech impairments?

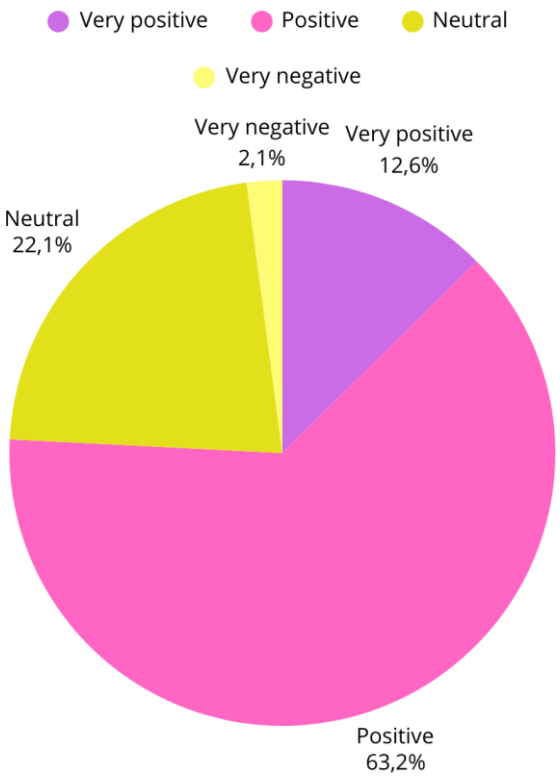
Speech-to-text, AI or not, also suffers with accents and dialects, especially reverse output to speech. 27.4% (n=26) of interview participants suffered from repeated recognition failure, complaining about an issue most of the time. 50.5% (n=48) expressed dissatisfaction only rarely during testing, however. Although 21.1% (n=20) reported failure occurrences at times, demonstrating overall reliability, additional tuning is obviously necessary. Surprisingly, a minor 1.1% (n=1) indicated that AI systems never crashed, again directing us toward diversified speech data and improved models instead of diversified speech patterns.



Question 16: How would you rate the overall impact of AI-based tools on the quality of language therapy?

The large majority of respondents (63.2%, n=60) perceive AI-based tools as having a positive effect on language therapy quality, consistent with general endorsement of their worth in enhancing therapy. Further, 12.6% (n=12) rate AI's effect as very positive, consistent with strong support by some users. However, 22.1% (n=21) are neutral, consistent with mixed experience or ambiguity regarding AI's effect. An even smaller group, 2.1% (n=2), perceive AI's effect as very negative, perhaps consistent with limitations or challenges they encotered. Overall, what is found

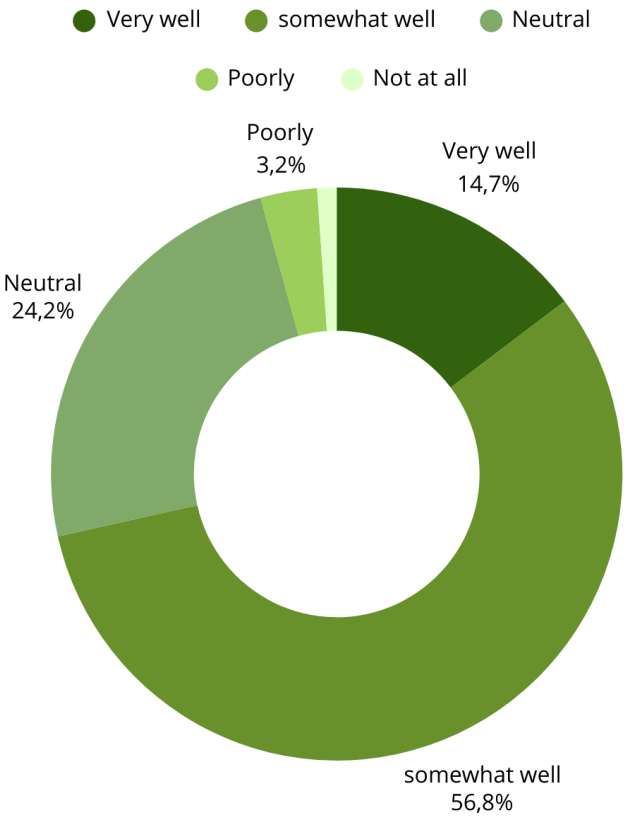
is that AI-based tools are generally viewed as useful but would be improved by changes to overcome reservations and maximize their potential for therapy.



Question 17: How well do you think technology integrates with traditional language therapy methods, improving collaboration between therapists and clients?

The largest group of respondents, 56.8% (n=54), are of the opinion that technology complements somewhat traditional language therapy practices, suggesting that although technology is useful, there is still room for limitations in seamless coordination between therapists and clients. Another 14.7% (n=14) are of the opinion that it complements very well, which is a strong positive opinion by a smaller group. Another 24.2% (n=23) are neutral, which can be taken to signify variability or ambiguity in experience. A smaller group of 3.2% (n=3) perceive that technology complements poorly and 1.1% (n=1) that it doesn't complement at all, perhaps because of challenges in adjusting to AI-based tools or challenges in sustaining a human touch. Overall,

although there is a perception that technology is enhancing coordination, there are still reservations regarding full incorporation into traditional therapy.



Question 18: What challenges have you encountered while using Al tools for language therapy?

Analysis of 71 responses helped to identify some key issues in applying AI for language therapy. In addition, precision and identification were key problems, since AI has historically been troubled by speech understanding difficulties in accent variations, dialects, and impairments in particular Afrikaans such as Algerian Arabic. Participants asserted that it uses a "one-size-fits-all" approach in applying AI tools and not genuinely industry-adaptable due to lack of one-off questions over linguistic and cultural matters. Also, issues of existence of problems in software glitches, slow re-action, and in-compatibility scenarios were highlighted several times. Amongst the toughest hits was that AI is quite far from emotionality—there is zero empathy/support/emotion detection in practice by the tools since they remain purely non-empathic

in relation to therapy. Some other consumers highlighted concerns of AI "bugging" them in terms of privacy as well as security issues which were an ethical dilemma for some. Others however were issues of affordability and availability since the best AI tools remain subscription-based and hardly attainable to everybody. Also in view were red flags hanging in the balance and ways in which AI has the potential to disempower therapists — over-reliance in using those tools to an extent at which there's zero human component in therapy. Additionally, insufficient training and in the fact that little training practicing even in AI tools left many consumers not even knowing exactly to use them. Another problem at play was misleading/false information since at times AI was generating false answers without any citations. Also, poor support for multilingual/multicultural adaptability left AI tools unable to perform in diverse environments. The premise of using AI has its positives however, to apply it effectively in language therapy without sacrificing human component— the speech recognition, personalization, emotional intelligence, accessibility, et al require massive changes.

III.3. Case Study Analysis:

III.3.1. Case Study Selection:

III.3.1.1. Justification for Choosing This Case:

The AI-Assisted Therapy for Rhotic Sound Disorders case study was sourced from a credible internet platform, as it is not available locally, and was chosen because it leads toward the research goal of determining AI’s contribution to speech therapy. It presents an actual instance of AI deployment in the clinic, indicating AI can manage long-term speech sound dis-orders successfully. The study is useful down the line because the condition that is being tackled—residual speech sound dis-orders (RSSDs)—has no traditional therapy to resort to. And the AI device utilized, PER-CEPT-R Classifier, provides instantaneous feedback and keeps track of improvement, providing definitive evidence of the role it serves in supplementing traditional modes of speech therapy.

III.3.1.2. Background on the individual/group studied:

Five participants who were diagnosed with residual speech sound disorders and were having trouble accurately producing the rhotic sound /ɹ/ (as in words like red or car) participated in the research. Ages ranged from 10 years and 7 months to 19 years and 3 months, showing the continuation of speech sound disorders into adolescence and young adulthood. All participants had

also received traditional speech therapy in the past and still struggled. The intervention included clinician-directed therapy combined with AI training where participants received immediate feedback from the PERCEPT-R Classifier while training /ɹ/ sounds. Accuracy in sound production was measured by the study before and after the intervention using AI. This case study represents an extreme case of the potential for using AI as supplementary therapy and providing new means for the treatment of chronic speech impairments.

III.3.2. AI Technology in Therapy:

III.3.2.1. Overview of the AI Tool:

The PERCEPT-R Classifier is an artificial intelligence-based speech analysis tool that has been developed in order to assist therapy for residual speech sound disorders (RSSDs), and most significantly the rhotic sound /ɹ/. It augments traditional therapy by providing immediate feedback and tracking pronunciation improvement.

III.3.2.2. Key Features and Functions:

- ✓ **Speech Recognition & Analysis** – Evaluates accuracy in the pronunciation of /ɹ/ sounds.
- ✓ **Immediacy Feedback**– Permits participants to self-correct instantly.
- ✓ **Progress Tracking** – Tracks improvement over time, benefitting both patients and therapists.
- ✓ **Data-Driven Adaptability** – Adapts based on learned information to improve accuracy in ratings.

This therapy instrument makes therapy more interactive and evidence-based so that patients who have chronic speech sound disorders have better outcomes.

III.3.3 Therapy Sessions:

- **Chaining AI Overview:**

Chaining AI is a web-based speech therapy program that seeks to treat the /ɹ/ sound. It evaluates speech to forecast performance and provides feedback in the form of Knowledge of Results (KR) and Knowledge of Performance (KP). Feedback is provided in the form of an avatar, text messages, voice instructions, and tongue position animations. Participants have to get the sounds correct prior to practice, and practice begins with simple sounds and progresses to complex

words and sentences. There are four trials for each block, a minimum of 3 correct to proceed. There are both visual and auditory cues employed, and subjects provide self-recorded speech to be scored. Random Practice is done 5 minutes prior to the end of the session, on hard sounds, with general advice for individuals who are still having trouble on easy sounds.

The study involved ten sessions of therapy comprising the utilization of Chaining AI to enhance /ɹ/ pronunciation in the participants. The 40-minute session was repeated three times a week for about 3.5 weeks.

III.3.3.1. Session Details:

III.3.3.1.1. Orientation (First Session): The participants were presented with the /ɹ/ sound and provided with initial training by a speech-language pathologist.

III.3.3.1.2. Pre-practice Exercises (10 Minutes): The clinician guided these sound awareness and articulation exercises, thereby allowing participants to practice beforehand before going on to the drill practice.

III.3.3.1.3. AI-Drill Practice (30 Minutes): Participants performed speech drills with the Chaining AI web application under clinician guidance with immediate accuracy feedback.

III.3.3.2. Participant Involvement & Responses:

- **Wonderful Experience:** Participants enjoyed the instant corrective feedback on their performance that directed them towards increased self-monitoring and engagement.
- **Independence Boost:** Participant use of this AI-driven method of instruction allowed them to practice autonomously apart from the clinician, and it promoted autonomy and minimized clinician reliance**.**
- **Some Confusion**: A few participants had difficulty understanding AI feedback at first and needed assistance from clinicians for clarification.

Multiple Baseline ABA Single Case Experimental Design was utilized in the study, and it entailed:

- Baseline 1 (Pre-Treatment): Participants were assessed for speech production without treatment to gauge from where they were starting**.**

- **Treatment Phase**: The participants underwent AI-chaining treatment sessions with Chaining AI and the clinician, including live feedback for mistakes during speech drills.

- **Baseline 2 (Post-Treatment):** The participants were tested again with treatment withdrawn to see whether skills acquired in the first phase of treatment persisted over a long period after withdrawal of AI.

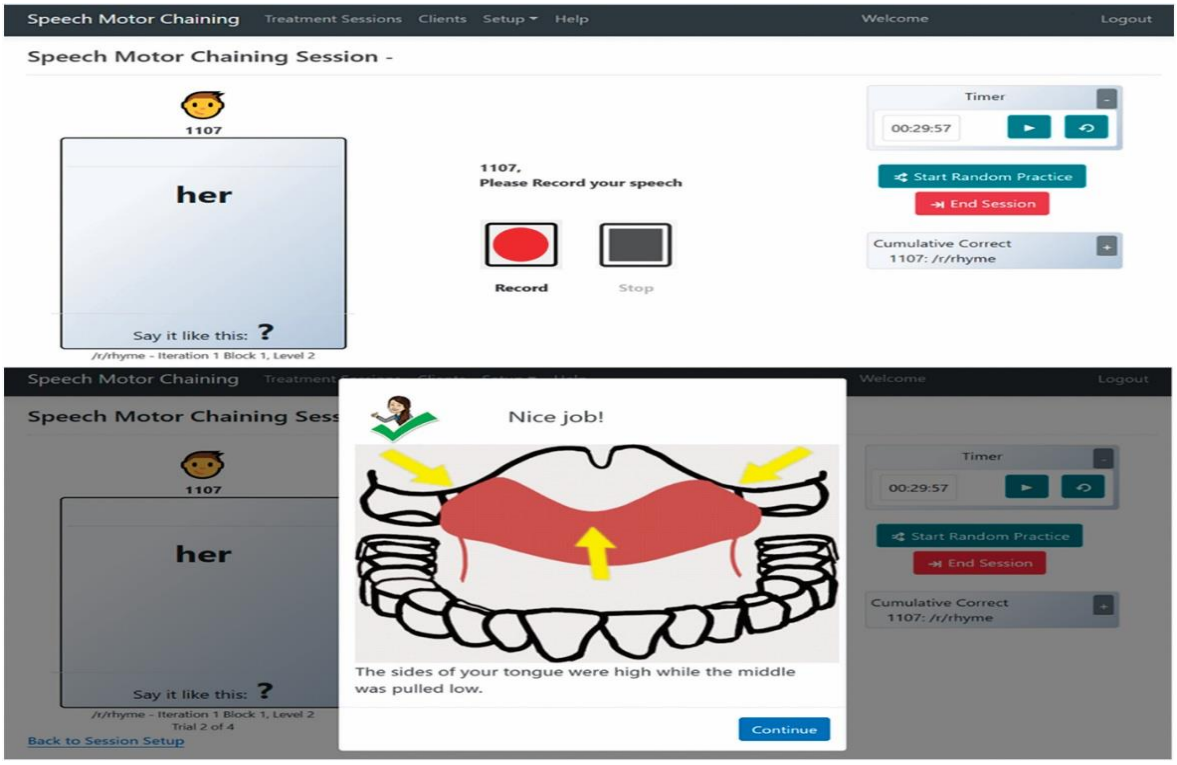


Figure III.1: Speech Motor Chaining

III.3.4. Treatment Target Selection and Word List Customization:

Treatment goals for all participants were specified in immediately after eligibility session, thus facilitating the tailoring of the baseline word lists. 2,361 /ɹ/-monosyllabic and /ɹ/-bisyllabic words were marked up and identified. Pre–post word lists included 100 words, with repeated lists included 60, which were to be phonologically balanced as well as suitably challenging for each participant.

Phonological features of target treatments were established by determining participants' accuracy with different phonological characteristics. Targets were mostly selected from situations where syllables were stimulable, allowing significant practice.

Table 1 depicts the treatment targets for each participant, separating practiced syllables, example chaining words, untreated word list compositions, baseline accuracy in untreated contexts, and example untreated words. The structured format identifies the individualized method of speech therapy, prioritizing practice and evaluation for maximum participant benefit.

Participant	**Syllables Practiced with Clinician**	**Example ChainingAI Chain**	**Untreated Word List Composition**	**Baseline Accuracy in Untreated Word List Context**	**Example Untreated Word List Item**
1107	/ɛɹ/, /ɑɹ/, /ɪɹ/, /ɝ/	Purr, perfect, perfect day	Nucleic/postvocalic monosyllables	2.7%	Burned
1111	/ɑɪɹ/, /ɛɹ/, /ɑɹ/, /ɝ/, /ɔɹ/, /ɪɹ/	Fire, firehouse, visit the firehouse	Monosyllables	16.9%	Spire
1112	/ɝd/, /ɹm/, /θɹ/, /ɹd/	Throw, throwing, throwing the ball	Monosyllables	24.6%	Frog
1121	/ɑɹ/, /ɝ/, /ɔɹ/, /ɹk/	Mark, marquee,	Unstressed /ɚ/, unstressed /ɹ/ in iambs	33.4%	Forbode

		names on the marquee			
1130	/ɑɹz/, /ɝz/, /ɑɪ/, /ɝ/, /ɛɪ/, /ɑɪt/	Hers, mother's, Mother's Day	Nucleic/postvocalic (monosyllable and bisyllables)	30.7%	Vampires

Table III.1: The Treatment Targets for Individual Participants

III.3.5. Findings and Cross-Analysis Observations:

III.3.5.1. Grand Patterns:

- **Measurable Improvement in Pronunciation:** Participants showed measurable improvement in rhotic sound /ɹ/ pronunciation after AI-treatment.
- **Increased Engagement and Autonomy:** Chaining AI interactivity provided increased engagement and autonomy compared to traditional approaches.
- **Prompt and Effective Feedback System:** Instant feedback enabled participants to correct themselves on the spot, facilitating learning.
- **Consistency of Progress:** Repeating to excess over specially prepared word lists ensured incremental, consistent progress.

III.3.5.2. Benefits:

- **Personalized Learning:** AI tailored to every individual's unique phonological requirement, with a single-to-single therapy session.
- **Low Clinician Workload:** Clinician-assisted sessions facilitated by AI allowed clinicians to concentrate on strategic interventions rather than rote drills.
- **Data-Driven Insights:** Monitor progress via AI and enjoy objective performance feedback in the long run.

3.5.3. Challenges:

- **Initial Struggle in Understanding AI Correction:** A few of the patients needed clinician support to comprehend AI corrections.

- **AI Misclassifications:** Isolated AI speech recognition misclassifications needed to be addressed by humans.
- **Retention Post-Treatment:** Treatment improvement was noted but minor regresses were observed on AI withdrawal in some of the subjects.

III.4. Comparison with Questionnaire Results:

III.4.1. Alignments:

- ✓ **High Engagement and Motivation:** Case study and questionnaire results both showed that AI-based treatment was more engaging in comparison to traditional methods.
- ✓ **Efficacy of Immediate Feedback:** Subjects in both the questionnaire and case studies all alike praised the application of immediate AI-corrected feedback.
- ✓ **Autonomy in Therapy:** Both the datasets included AI therapy, and it allowed the patients to be independent of the clinician.

III.4.2. Contradictions:

- ✓ **Perception of AI Accuracy:** The questionnaire respondents did not think that AI was accurate while interpreting speech, but in case studies, the students mostly considered AI feedback correct but with minor errors.
- ✓ **Long-Term Retention:** Case study findings revealed some error in pronunciation following AI removal, while questionnaire respondents were optimistic about AI's long-term viability.

The findings reveal that therapy with the assistance of AI significantly enhances activity, accuracy, and independence in speech therapy. However, there are some limitations that still prevail, including interpretation of feedback and long-term retention of skills. Cross-analysis validates that while AI is an extremely promising technology, human facilitation is at the centre of being able to utilize it to its fullest potential.

Conclusion

Integrative results of questionnaire and case study strongly validated that AI-supported speech therapy enhanced significantly speech therapy with improved treatment of rhotic sound disorder, pronunciation, motivation, and self-regulation. The case study concluded that AI-supported software such as PERCEPT-R Classifier and Chaining AI was useful to enhance normal

therapy with remedial real-time feedforward and sequentially sequenced sequences of learning sequences. Participants showed marked improvement in /ɹ/ production, motivation, and self-regulation. Consistently throughout questionnaires, participants preferred AI therapy by a wide margin due to interactivity and engagement, pointing to the erosion of clinician autonomy. Despite the above, considerable differences between the two data sets did arise. Although case study participants would presumably be convinced about AI corrective feedback, questionnaire results indicated lack of confidence in the ability of AI to interpret speech. Other than that, although the test subjects anticipated AI to copy itself in the long run, the case study concluded with minimal regression in pronunciation upon withdrawal of AI support as a sign of maintenance difficulty in skills following intervention. Even if such are the drawbacks of AI therapy, there exist also certain strengths in AI therapy which stem from the nature of the very approach itself, e.g., reduction of clinicians' workload, evidence-based suggestions, and customization of treatment by need according to intervention. Success hinges upon human involvement through correct translation of inputs from AI alongside long-term continuation of gains. Future research will have to develop improved error classification algorithms for AI, facilitate effective long-term recall of acquired skills, and examine hybrid blends of AI-human treatments. AI, in transforming the practice of speech therapy, is not meant to replace clinicians but is a tool that, when appropriately integrated, maximizes outcomes.

General Conclusion

General Conclusion

This study has explored the evolving aspect of language therapy, focusing on the interchange between traditional therapeutic methods and emerging technological approaches. The study showed that language therapy plays in improving communication skills and quality of life for affected patients. Using mixed-methods involving observations, questionnaires, and a rich case study, it sought to determine how technology tools could benefit and supplement speech therapy and therapy practices with limited resources to facilitate traditional speech therapy practices.

The first chapter explored traditional approaches to language therapy, including methods like Van Riper's articulation therapy and phonetic placement techniques; also, identifies and provides a description of the various types of language and speech disorders. These strategies are firmly anchored in behavioral and developmental orientations that prioritize narrowly defined, consistent, and repetitively practiced task completion while being monitored or supported by the therapist. It examined various language and speech disorders including receptive and expressive difficulties, speech impairments, and language-based learning disabilities. Though a discussion about the importance of feedback in language therapy, underline how different types of corrective feedback support fluency, accuracy, motivation, and learner autonomy. Research findings and examples are provided to show how feedback loops affect learning and client commitment.

The second chapter explored the rapid advancement of digital tools and artificial intelligence, a new era of language therapy is emerging. The chapter outlined how these technologies are not only transforming how therapy is delivered but are changing access to intervention that was not feasible before especially in many isolated, underserved or resource

impoverished areas. Digital technologies such as mobile apps, telepractice platforms, AI-based assessment tools, and virtual reality simulations offer powerful ways to supplement our traditional practice. For example, AI programs that deliver real-time corrective feedback, avatar-guided therapy sessions, and interactive games to intervene on articulation or language understanding was explored. The chapter indicated that AI-powered applications, mobile platforms, and virtual therapy tools have significant prospective to complement and enhance traditional practices. It included Natural Language Processing (NLP), speech recognition, machine learning, and deep learning algorithms. It also expressed how technology and modern methods can enhance speech language therapy by helping therapists in their work and diagnoses with patients

The third chapter included the results of questionnaire that strongly validated that AI-supported speech therapy enhanced significantly speech therapy with improved treatment of rhotic sound disorder, pronunciation, motivation, and self-regulation. Confirmed with a case study wich used two AI tools, the PERCEPT-R Classifier and Chaining AI, to provide rich examples of the potential uses of AI with adressing the issue of persistent rhotic sound disorders. Improving the articulation skills (pronunciation) of participents, demonstrated higher levels of engagement and autonomy during therapy sessions, benefitted from immediate feedback from the AI systems, could engage with and track their data when working independently and had individual learning paths that could not otherwise be accomplished by traditional therapies. the study also pointed out several notable limitations, including the initial difficulty of making sense of AI feedback, the occasional misclassifications made by the AI tools, and issues with consistency in a patient retention of skills after the withdrawal of the AI.

This dissertation emphasizes the importance of an integrated approach that combines the

strengths of regular therapy with the benefits of modern technological revolutions. As a result, interpreters may offer more effective, workable, and inclusive solutions that meet the various needs of individuals with language and communication disorders. Instead, a hybrid approach to therapy using AI based tools with face-to-face professional oversight seems to be the most reasonable approach to modern language therapy. Further research is needed to assess the long-term impact of these tools and to develop best practices for their integration into clinical settings.

Limitation of the Study:

Our study is limited by different factors. Firstly, the research was led with a relatively small number of speech-language therapists and patients due to the limited availability of professionals working across multiple clinics and institutions in our city. This may affect the generalizability of the results to a broader clinical population. Secondly, our topic of integrating artificial intelligence and digital tools into language therapy is still relatively new and under-researched in Algeria. As a result, there was a noticeable lack of region-specific literature and resources, many of which were either isolated or available only through paid platforms. This may have limited the depth of the literature review and background context. Thirdly, limitation lies in the varying levels of digital literacy among participants, which may have influenced their perceptions of technology-based therapy methods. Furthermore, people’s limits in general culture have made us collect less information than we wanted, especially in our questionnaire. Lastly, due to the diversity in patients' language disorders and therapy experiences, standardizing answers across different cases demonstrated challenging.

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Appendices

Appendix A: Questionnaire

Within the framework of completing a master's dissertation entitled "the Impact of Technology on Language Therapy", We put in your hands this questionnaire, asking you to kindly answer all its questions accurately and objectively, in the circle that agrees with your opinion, by putting a mark (\) . Note that our information will be used for scientific purposes only. You are kindly requested to fill in this questionnaire. All information and participants' identities will be kept confidential and anonymous. Thank you for your time and cooperation.

1. Gender:

o Male.

o Female.

2. Age: …….

3. Occupation: ……

Section one:

The question yes no unsure

1. Have you noticed any differences in the progress of clients

using technology versus those using traditional methods?

- o Yes
- o No

2. Do you think technology-based tools encourage

independence in language learning for clients?

- Yes
- No

_ How familiar are you with the use of technology in language therapy?

- Very familiar
- Somewhat familiar
- Not familiar at all

_How often do you use technology (apps, software, etc.) as part of your language therapy sessions?

- Daily
- Weekly
- Monthly
- Rarely
- Never

_What specific features of speech recognition tools do you find most helpful in language therapy?

- Immediate feedback
- progress tracking
- Customized training exercises
- User-friendly interface
- other

_What age group do you think benefits the most from technology-assisted language therapy?

- Children
- Adolescents
- Adults
- Seniors

_How sustainable do you think the use of technology is for long-term language therapy

outcomes?

- Sustainable
- Neutral
- Not sustainable

_What factors influence your decision to adopt a particular tool or app for language therapy?

(e.g., cost, user reviews, features, etc.)

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Section two :

The questions Yes No Unsure

1. Are you aware of the role of artificial intelligence (Al) in

language therapy?

- Yes
- No
- Unsure

2. Have you used any Al-based technology or software tools in

language therapy?

- Yes
- No
- Unsure

3. Do you feel that using Al tools for language therapy accelerates

the learning process?

- Yes

- No
- Unsure

4. Have you encountered any challenges while using Al tools for

language therapy?

- Yes
- No
- Unsure

5. Do you believe technology-based tools are equally accessible to

clients of all socioeconomic backgrounds and technical skills?

- Yes
- No
- Unsure

6. Do you believe Al and technology should be integrated more into

language therapy practice?

- Yes
- No
- Unsure

Agree/Disagree Questions

1. Al and technology improve both specific skills (e.g., pronunciation) and overall therapy outcomes.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

2. Therapists need more training to effectively use technology in language therapy.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

3. The cost of technology-based tools is a barrier to their widespread adoption in language therapy.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

4. Technology-based tools encourage independence in language learning for patients.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

_How often do you feel Al-based tools fail to recognize speech correctly due to accent, dialect, or speech impairments?

- Frequently
- Occasionally
- Rarely
- Never

_How would you rate the overall impact of Al-based tools on the quality of language therapy?

- Very positive
- Positive
- Neutral
- Negative
- Very negative

_How often do you feel Al-based tools fail to recognize speech correctly due to accent, dialect, or speech impairments?

- Very easy
- Somewhat easy
- Neutral
- Somewhat difficult
- Very difficult

_How well do you think technology integrates with traditional language therapy methods, including improving collaboration between therapists and clients?

- Very well
- Somewhat well
- Neutral
- Poorly
- Not at all

_Do you participate in workshops or conferences to stay updated on technological advancements in language therapy?

- Regularly
- Occasionally
- Rarely
- Never

_Are you concerned about the privacy of client data when using Al-based tools in therapy?

- Very concerned

- Concerned Neutral Not very
- Concerned
- Not concerned at all

_How important is data security and client confidentiality when choosing a technological tool for therapy?

- Very important
- Somewhat important
- Neutral
- Not very important
- Not important at all

_What challenges have you encountered while using Al tools for language therapy?

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Summary

This dissertation examined the impact of technology on language therapy by comparing traditional therapeutic methods with digital interventions. The results suggest that while conventional therapy stands the foundation of speech-language rehabilitation, technology-based approaches such as teletherapy, artificial intelligence (AI)-driven programs, and mobile applications that offer notable benefits, including increased accessibility, real-time feedback, and personalized learning experiences. However, concerns regarding the reduction of face-to-face interaction, the need for therapist supervision, and potential disparities in technology access stand challenges to widespread adoption.

Résumé

Cette dissertation a examiné l'impact de la technologie sur la thérapie du langage en comparant les méthodes thérapeutiques traditionnelles aux interventions numériques. Les résultats suggèrent que, bien que la thérapie conventionnelle constitue la base de la rééducation de la parole et du langage, les approches basées sur la technologie telles que la télé thérapie, les programmes alimentés par l'intelligence artificielle (IA) et les applications mobiles offrent des avantages notables, notamment une accessibilité accrue, un retour en temps réel et des expériences d'apprentissage personnalisées. Cependant, des préoccupations concernant la réduction de l'interaction en face à face, la nécessité d'une supervision par les thérapeutes et les disparités potentielles dans l'accès à la technologie constituent des défis pour une adoption généralisée.

ملخص

درست هذه الأطروحة تأثير التكنولوجيا على العلاج اللغوي من خلال مقارنة الطرق العلاجية التقليدية بالتدخلات الرقمية. تشير الاكتشافات إلى أنه في حين أن العلاج التقليدي يمثل أساس إعادة تأهيل النطق واللغة، فإن النهج القائمة على التكنولوجيا مثل العلاج عن بعد والبرامج القائمة على الذكاء الاصطناعي (الذكاء الاصطناعي) وتطبيقات الهاتف المحمول التي توفر فوائد ملحوظة، بما في ذلك زيادة إمكانية الوصول والتعليقات في الوقت الفعلي وتجارب التعلم المخصصة. ومع ذلك، فإن المخاوف المتعلقة بالحد من التفاعل وجها لوجه، والحاجة إلى الإشراف على المعالج، والتفاوتات المحتملة في الوصول إلى التكنولوجيا تمثل تحديات أمام التبني على نطاق واسع.


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