The Impact of Artificial Intelligence (AI) in the Assessment and Treatment of Communication Disorders (A Review of Literature)

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Abstract: ***The present study investigates how artificial intelligence (AI) and machine learning (ML) can significantly affect the assessment and treatment challenges concerning communication disabilities. It highlights the importance of early and precise diagnosis of communication disabilities, which are frequently impeded by clinical and genetic variability. It illustrates how AI and ML are reshaping healthcare, and as such providing examples of their effectiveness in diagnosis, assessment, as well as treatment plans revealing case history and therapeutic plans like the effective treatment programs.***
Further, the study demonstrates how AI can quickly and accurately diagnose patients and analyze large datasets in an efficient manner. It also explores how AI tailor's treatment plans for different communication disorders, providing the ML and deep learning (DL) to develop personalized treatment plans.
The development of health databases and the possibility for tailored treatment recommendations are two areas with which speech and language therapy successfully deal as a result of the integration of AI with human health care.The study covers ethical, legal, technical as well as human elements concerning healthcare AI limitations as well.
In summary, the study provides a comprehensive exploration of the recent influence of AI on speech and language therapy and offers speech and language pathologists (SLPs) a number of tools that help patients achieve therapy objectives. AI tools can, indeed, help speech-language pathologists (SLPs) in practical therapeutic applications by offering useful data regarding practice performance. In addition to the usage of the AI, Language models help patients receive effective therapy and achieve better speech outcomes.

Keywords*: Communication disorders, Language and Speech Disorders, Assessment and treatment, Artificial Intelligence (AI), Machine Learning*

1 INTRODUCTION

As much as 1% of the global population has speech, language, and communication needs (SLCNs). According to recent empirical research, 8% of kids between the ages of three and seventeen suffer from communication disorder, which is described as a speech, language, voice quality, or swallowing issue problem. A communication deficit can also lead to a problem with words, their usage, and comprehension. Reducing communication issues is crucial since poor language and communication skills have a detrimental effect on a child's behavior and development. This is because their ability to learn from their environment, reach their full cognitive potential, and they interact socially, and so are severely compromised. Murero et al. (2020)

Artificial Intelligence (AI) is concerned with computer programs that carry out tasks created by human intelligence, such as perception, speech recognition, learning, reasoning, problem solving, and natural language understanding; in fields like art, education, health, medicine, robotics, security, and surveillance, artificial intelligence (AI) developers produce software that can mimic human cognitive processes and, in certain situations, even outperform them. Machine learning (ML), which creates algorithms to learn from data in cyberspace, is one type of AI as well. In contrast to computer programs designed for specific purposes, Machine learning (ML) generates rules and configurations based on patterns found in large data sets gathered over many years and in a select few popular languages. For instance, with the use of open-source AI algorithms that are trained using one or two verbal cues (words), deep learning creates neural networks using speech and image data by identifying recurring patterns in the code. NLP models enable deep learning to comprehend, analyze, and produce language output being useful for text analysis, chatbots, medical diagnosis, and language translation. What, indeed, underpins Chat-GPT, is the NLP. In addition to being utilized for picture or video recognition, object detection, face recognition, and automobiles, computer vision also allows

machines to analyze and make judgments based on visual data without receiving verbal input. Robotics enables robots to see and interact with items in their surroundings, and this enables them to carry out manual tasks required in production, healthcare, and exploration. Expert systems are AI programs that use databases with "inference engines" to solve problems and give advice, similar to human experts in a particular field. This can be observed in virtual therapy, where chatbots offer guidance and problem-solving assistance. AI-powered reinforcement learning software for gaming, robotics, and voice therapy is among the software tailored for the healthcare and rehabilitation industries; see Hamet et al (2017)

Theoretically, AI has vast and interact theoretical basis; AI information content, entropy, and uncertainty can all be measured mathematically using tools of information theory. Patterns, relationships, and structures in data are represented and analyzed using graph theory. AI uses graph theory algorithms for tasks including recommendation systems, NLP, social network modeling, and network analysis. For machine learning, planning, game theory, and constraint satisfaction, optimization theory employs combinatorial and linear programming. In scientific computing and computational intelligence, numerical techniques can be applied to solve equation systems, optimize algorithms, and simulate-based approaches. Control theory is used in AI to develop autonomous systems, robotics, adaptive control, and reinforcement learning. It deals with the analysis and design of dynamic systems and feedback control mechanisms. Mathematical concepts from statistics, probability, calculus, and linear algebra are all used in AI algorithms. Additionally, the reciprocal interaction between AI and aphasiology is also given. One instance of a statistical technique used in artificial intelligence and a basic neural network is logistic regression. Interestingly, thirty years ago in London, aphasiology experts were the ones who first recommended the use of logistic regression. Using a logistic function known as the sigmoid function, which converts the input to a probability score between 0 and 1, logistic regression models the relationship between independent variables and PWA performance using a linear classification approach for binary classifications. Logistic regression was initially used to analyze binary responses in single case data, then group data. Currently, it is applied to assess therapy effectiveness, detect risk factors, and improve recovery in aphasia and other health sectors. While logistic regression models function similarly to simple linear neural networks, deep learning models use larger datasets and more advanced self-teaching algorithms to capture intricate non-linear correlations. Weekes et al. (1998)

2 INTEGRATION OF ARTIFICIAL INTELLIGENCE (AI) IN THE ASSESSMENT AND TREATMENT OF DIFFERENT COMMUNICATION DISORDERS

Some of the algorithms and tools that compensate for communicative and cognitive limitations include intelligent assistive technologies and augmentative and alternative communication (AAC) are discussed below: -

- Automatic Speech Recognition (ASR) It is possible to train systems to identify a certain set of words that most people may find difficult to recognize. The information can then be shown by the system either orally (text) or visually (synthesized speech). The user must know how to spell or know the sentence they wish to utter in order to use the majority of basic AI systems. The main goal of the improvements is to offer a corpus of frequently used words and phrases as a better "starting point." Wormald (2023)

- Voice banking AI can also facilitate communication through voice banking. People with conditions including Parkinson's disease, expressive dysphasia, and various forms of dysarthria; populations who may someday lose their ability to communicate verbally often employ this technology. An individual may use a web-based platform to occasionally record the voice. Compared to standard text-to-speech software, the synthesized speech produced from these voice samples are more like an individual. Since our voice is an integral element of who we are, this approach enables a person to keep the perception of him/ herself and others consistent. Wormald (2023)

- Better Speech Speech-recognition and language-processing abilities that can assess speech patterns identify areas for improvement, and deliver targeted interventions" are continually being improved by Better Speech's generative AI-powered speech therapist, "Jessica." Ortiz (2023). Additionally, the company states, "our software is designed to augment our service and serve as a practicing tool, not to replace our Speech Therapists".

Examples on the interaction between AI and the treatment of some communication disorders

A. Stuttering Rehabilitation and AI

Detecting stuttering: AI tools can listen to speech patterns and pinpoint exactly when and how stuttering occurs. This is like having a highly skilled therapist who can catch every stutter, even those that might not be obvious. Albanaaet al. (2022)

Personalized therapy: By understanding each person's unique speech patterns, AI can help create customized therapy plans. This means therapy can be more effective because it targets the specific needs of each individual. Albanaaet al. (2022)

Improving accuracy: Traditional methods might miss subtle stutters or misclassify them. AI, its quick analysis of huge amounts of data, reduces these errors, offering a clearer picture of a person's speech challenges. Albanaaet al. (2022).

B. Hearing Impairment Rehabilitation and AI

Enhancement of hearing aids as important tools for treatment: Modern hearing aids, equipped with AI and machine learning algorithms, do more than amplify sound. They distinguish between speech and noise, and adjust the tool settings to optimize the user's auditory perception in real-time to optimize the user's hearing experience in various environments. Albudooret al.(2022)

AI improves speech clarity in noisy environments

A core challenge for people with hearing loss is to understand speech in noisy settings. AI-powered hearing aids tackle this by processing, identifying and amplifying speech, making it easier for the user to understand conversations even in noisy environments Albudooret al.(2022) .

This not only aids in more effective communication but also supports the goals of speech therapy by improving the wearer's ability to engage in conversational speech and comprehend spoken language in complex acoustic environments.

Direct Applications in Speech Therapy: For speech therapy specifically, the advancements in hearing aid technology mean therapists can utilize these devices as part of their therapeutic toolkit. By improving the audibility and clarity of speech sounds, hearing aids help individuals practice and reinforce speech therapy techniques in real-life scenarios, thus bridging the gap between therapy sessions and daily communication needs.

C. AI and Neurological disorders Rehabilitation

AI has the potential to advance speech therapy through brain-computer interface (BCI) technologies. By analyzing EEG signals, AI algorithms can interpret the brain's electrical activity as speech, offering new communication avenues for individuals with severe speech impairments. American Speech-Language-Hearing Association (2023)

This approach bridges audiology and speech therapy by translating thought into spoken word, bypassing traditional speech production pathways. Techniques such as support vector machines and deep learning, particularly convolutional neural networks, have shown improvement and made progress in decoding imagined speech, underscoring the synergy between AI's analytical capabilities and the therapeutic goals of speech therapy. This integration could dramatically enhance treatment options for speech disorders, underscoring the importance of interdisciplinary collaboration in harnessing AI's potential for healthcare.

D. AI and Laryngeal /Voice disorders Rehabilitation

Artificial intelligence (AI) has recently become a viable diagnostic and therapeutic tool for laryngeal diseases. Laryngeal cases are often diagnosed based on subjective evaluations made by qualified medical personnel. Nevertheless, inter-rater variability and the evaluator's own prejudices may have an impact on these evaluations. Conversely, artificial intelligence systems possess the ability to impartially examine speech recordings and offer a numerical evaluation of voice quality. The acoustic voice analysis (AVA) tool is one instance of an AI system. The AVA tool analyses speech recordings using machine learning techniques and offers a neutral evaluation of voice quality. It can pick up on minute variations in speech quality that a human ear might miss. Vocal fold paralysis, dysphonia, and laryngeal cancer are among the laryngeal disorders for which it has shown effective in both diagnosis and follow-up. The differential diagnosis of laryngeal problems can also benefit from the use of AI systems. A small number of studies found that AI systems could reliably distinguish between various forms of dysphonia with a 90% to 95% sensitivity and an 80% to 85% specificity. This shows the promise of AI in the identification of laryngeal problems, as its accuracy level is on par with that of skilled human evaluators. Kumar et al.(2023)

E. AI and Aphasia Rehabilitation

The “semantic decoder” is an AI assistant technology and is able to translate brain activity into written text for people suffering from aphasia. It was created by researchers at the University of Texas. The device is still in progress and it is about 50% accurate.

The “semantic decoder” could be a great revolution for aphasic people; as It’s non-invasive device that’s mean that the “semantic decoder” does not require surgery and is not invasive in any way. Instead, it works through magnetic resonance imaging (MRI) scans measuring brain activity and signals.

This technology requires users to train hardly by listening to hours of podcasts while the device is scanning the brain activities. After the training is complete, the decoder is still currently accurate only about half of the time. Also , this device produces continuous text; that’s mean that the “semantic decoder” is able to continuously produce text and learns new words based on the training it is provided , this is opposite to other similar decoding technologies that provide the aphasic people with a set list of words that they are able to use. Then, they can only produce short sentences based on these word lists.

Aims of the study

1- *To illustrate the great impact of the AI the speech and language therapy as a means to improve diagnosis and treatment results for a range of communication problems.*

2- *To present some of the advantages of AI that may help the speech therapist in the way to examine the huge quantities of data from patient interactions, which enables the therapists to better personalize interventions to each patient's needs. Thus, the therapy sessions can be considerably more effective due to this personalized approach.*

3- To show the facilities provided by the AI to the patients ; as the immediate feedback during therapy sessions that enabling them to instantly modify their speech habits , and the its accessibility and convenience for those living in remote places or being unable to see a therapist on a regular basis, patient can practice regularly at home without continual supervision. Also, its quick evaluation of speech patterns objectively and record changes as they occur, giving therapists precise information to follow their progress.

Significance of the study

Despite the AI promise, the integration of AI into speech therapy faces hurdles, such as the need for diverse and comprehensive speech datasets. The study presents the potential of some of AI tools that can transform the assessment and treatment of communication disorders from depending on tradition techniques and tools to use AI tools and programs that can serve a broad spectrum of individuals facing communication disorders and how it can support for neurodivergent individuals; AI has the potential to help people with neurodivergent diseases like attention deficit

hyperactivity disorder (ADHD) by helping to organize work, set reminders, simplify instructions, and accomplish therapy tasks more effectively.

3 LITERATURE OF REVIEW

Some studies done on *stuttering detection using computational intelligence and AI assessment***,** Ravin and Palanivelan (2021) goal of their research study was to apply deep learning to the individual classification of disfluencies, which would improve individuals' self-evaluation and provide an accurate assessment. However, it should be noted, nevertheless, that employing more training periods resulted in longer model run times; as such, this needs to be considered for future improvements.

Furthermore, Sheikh et al. (2021) highlighted the intention to investigate the field of numerous disfluencies disorders further in future study. Their study goal was to investigate more complex "Time Delay Neural Network" (TDNN)[1] variants for stuttering detection in practical contexts. In order to contribute to a more thorough knowledge of stuttering patterns in spontaneous speech, this breakthrough attempts to address the complexity of stuttering, where several disfluency types can co-occur.

In an effort to improve on already-existing AI models, Kourkounakis et al(2020) conducted a research on multiclass learning for various kinds of stuttering taking into account that various stuttering kinds may occur in a sentence together, this method might result in a more reliable categorization of stuttering with different types and degrees.

In hearing impairments field, an automated software for diagnosing hearing impairments was evaluated in a recent study by Taylor & Sheikh (2024). Its purpose was to help otolaryngologists and audiologists to accurately and efficiently diagnose and classify hearing loss. The software was based on machine learning. They create open-source automated software for diagnosing hearing impairments. It consists of two modules: a machine learning model and a module that generates data from hearing tests. They also analyze its performance. For the purpose of training and assessing the machine-learning model, the data-generation module generates a comprehensive and varied data set. Through the use of multiclass and multilabel classification algorithms, the model is able to reliably predict the type, degree, and configuration of hearing loss based on data from hearing tests. With a prediction time of 634 ms, a log-loss reduction rate of 0.9848, accuracy, precision, recall, and f1-score of 1.0000, the suggested machine-learning model illustrates promising results. The results demonstrate the model's ability to help otolaryngologists and audiologists quickly and accurately to classify the type, degree, and configuration of hearing loss.

Also, the effective role of the tele-audiology into speech therapy is addressed in research. Tele-audiology addresses multiple barriers to hearing healthcare, including geographical, financial, and logistical challenges. Tele-audiology, powered by AI, extends beyond traditional audiological care, offering remote hearing screenings, diagnostic tests, intervention, and rehabilitation. By providing services remotely, AI can enable individuals in remote or underserved areas to receive timely and effective audiological care, thereby supporting concurrent speech therapy programs. This approach is beneficial for patients and healthcare providers, allowing for a more efficient allocation of resources and enabling specialists to reach a wider patient base. American Speech-Language-Hearing Association. (2016)

The creation of AI algorithms to enhance the sensitivity and specificity of at-home otoscopy, improving remote diagnosis and treatment of ear disorders, is, indeed, an important breakthrough in tele-audiology. Additionally, smartphone-based machine learning algorithms have been used to detect middle ear fluid, demonstrating the potential for AI to enhance diagnostic accuracy in tele-audiology. AI-powered tele-audiology significantly benefits speech therapy by ensuring that individuals with hearing impairments receive timely and effective support, which is crucial for the successful treatment of speech disorders. By leveraging tele-audiology services, speech therapists can work in

[1] Is a multilayer artificial neural network and was presented in 1980 and performed on phonemes classifications used in speech recognition by showing segment accurately together with segment boundaries. TDNN detects the phonemes and their acoustic/phonetic characteristics, independent of time intervals, it's performed on two-dimensional the time-frequency patterns in speech, and coordinate space pattern in optical character recognition (OCR)

concert with audiologists to provide a cohesive treatment plan that addresses patients' audiological and speech-related needs.

Moreover, AI-driven tele-audiology services, such as remote hearing aid fittings and cochlear implant programming, may empower patients with more control over their care, potentially leading to increased satisfaction and adherence to treatment plans. American Speech-Language-Hearing Association. (2016)

Researches done on using AI in stroke and aphasia field, the study done by Azevedo et al. (2023) on the development of intelligent systems that can identify aphasic speech using Automatic speech recognition (ASR) has been the subject of his significant research, with the ultimate goal being their integration into therapy. Their results showed how the ASR recognize the speech input from the aphasic patient and provide real-time feedback response to their mistakes. In addition to its accuracy that depend on phoneme recognition, continuous speech, idiolect and environmental differences and the human language understanding of the given speech. Their conclusion stated great development of ASR technologies and its performance for individuals with speech and language disorders.

Le and colleagues (2018) developed and tested an Automatic Speech Recognition (ASR) system that would enable the Speech and Language Pathologists (SLPs) to accurately analyze large amounts of aphasic speech data. The system made relatively few ASR errors, according to the results, and it might be able to help SLPs with clinical diagnosis and/or progress tracking. They were concerned to point out, nonetheless, that evaluations indicated that people with severe aphasia would probably have significant difficulties utilizing programs that primarily relied on ASR output, even though they would be helpful to SLPs. In order to function as a virtual therapist, Abad and colleagues introduced the VITHEA[2] online system in 2013. This system included the AUDIMUS automatic word naming recognition module from ASR, which allowed Portuguese-speaking aphasic patients who had trouble finding words to complete word naming training exercises. The system performed well in identifying and interpreting aphasic speech, or words that are provided one at a time, as well as determining if the words were spoken correctly. However, it was remarked that it was uncertain if the accuracy attained was adequate for a positive user experience and whether it helped the individuals recover.

Barbera and colleagues more recently, in 2021, have developed a similar method (named NUVA) to automatically evaluate word naming efforts using ASR, but with an emphasis on English speakers. Additionally, the system correctly distinguished between correct and incorrect naming efforts and successfully recognized and processed aphasic speech. Although NUVA's performance was both more accurate and less variable than VITHEA's, it was noted that more validation with a wider sample of Progressive Web Application (PWA) is still needed, and that their performance statistics, while encouraging, can only be viewed as a proof of concept.

Two other research attempted to improve communication for aphasics by utilizing AI in aphasia therapy interventions. (Behrns et al., 2009; Fu & Ho, 2010). The two pieces of research concentrated on several linguistic modalities in an effort to support or enhance their capacity for communication. In the first study, Behrns and colleagues (2009) evaluated whether writing difficulties could be reduced in three Progressive Web Application(PWA) with a 9-week intervention of training on one of the two aids, either a word prediction program (SaidaH (Oribi AB)) or a spell checker program (StavaRätt 3.0H (Oribi AB)). They used two commercially available computerized writing aids that employ AI. According to the research results, employing a computerized writing tool might assist PWA develop solutions for problems with writing by speeding up the word-generation and correction processes. Additionally, this led to the generation of a proportionately higher number of correctly written words.

Fu and Ho (2010) intended to create an intelligent and user-friendly Finger Language Recognition Subsystem to assist aphasics in naturally completing everyday communication tasks. A data glove that collects finger language inputs, a finger language recognition subsystem that interprets the inputs, and a virtual keyboard that generates text from the inputs are all features of this intelligent communication system.

[2] Virtual therapist for aphasia treatment is online platform helps to recover naming of the words to the aphasic patients.

4 CONCLUSION AND RECOMMENDATIONS

In conclusion, Speech-language therapists as well as their clients should all benefit from the potential revolution that digital treatments and artificial intelligence provide. Digital therapeutics and (AI) are reshaping speech-language therapy with their capacity to improve therapy outcomes, expedite therapy processes, and personalize therapy.

The research study recommends the following: -

1-Most of the schools are facing a shortage of speech-language therapists, an AI-powered virtual speech-language therapy assistant was introduced to support students with communication disorders. The virtual assistant utilized natural language processing and speech recognition technologies to engage students in conversation and provide personalized feedback and guidance. Students could practice their communication skills independently, receiving immediate feedback and adaptive interventions. The virtual assistant also tracked students' progress and provided regular reports for therapists to review. The implementation of the virtual assistant significantly improved access to therapy, increased student engagement, and resulted in measurable improvements in the student' communication abilities.

2- The automatic analyzed language data performed by the AI tools including the different language areas, such as phonology, morphology, syntax and pragmatic skills can be a norm to compare between the normal language and the deviated language resulting from different communication disorders. This will reduce the time required for manual scoring and analysis in assessment plans for the patients and will to develop good and intervention plans and therapeutic plans.

3-Recommendation to start using the virtual reality (VR) technology and to integrate it in the speech and language therapy sessions to create realistic virtual environments where students could practice social communication skills in a controlled and immersive setting ; the VR system provided interactive scenarios, such as simulated conversations and social interactions, allowing students to practice appropriate communication behaviors.. The use of VR technology enhanced student engagement, provided a safe and supportive environment for practice, and resulted in improved social communication abilities among the students.

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BIOGRAPHY

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تأثير الذكاء الإصطناعي فى تقيم و علاج اضطرابات اللغة و التواصل (دراسة نظرية)

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المستخلص:

يُعد الذكاء الاصطناعي من أهم التقنيات الحديثة فى مجال التكنولوجيا الذكية،والتي فتحت مجالا واسعا للتطور في عدة مجالات ، و منها مجال اضطرابات اللغة و التواصل ؛ مثل الإعاقة العقلية ،و طيف التوحد، و غيرها من الإعاقات.

تهدف هذه الدراسة إلى التعرف على أثر الدمج التقني للذكاء الاصطناعي، وإمكانياته في التعامل مع اضطرابات اللغة و التواصل و كيفية التشخيص المبكر للاضطرابات اللغوية و النطقية المختلفة، بالإضافة إلى قدرته على تصور تقييم شامل للحالة و كذلك وضع خطة علاجية مقترحة. وقد تم الاعتماد فى هذا البحث على المنهج الوصفي ، و عمل مسح لبعض الدراسات السابقة التى تمت على تطبيقات الذكاء الإصطناعى فى مجال اضطرابات اللغة .و تبرز الدراسة كذلك الجوانب الأخلاقية والقانونية والتقنية بالإضافة إلى حدود الالمتعلقة بحدود استخدام الذكاء الاصطناعي في مجال اضطرابات التواصل. و أسفرت النتائج عن عدة نقاط:-

•يُعد الذكاء الاصطناعي أداة فعالة يمكن أن تساهم في تطوير علم اضطرابات اللغة و التواصل من خلال توظيف إمكانيات الذكاء الاصطناعي وتقييم تأثيره في جودة البيانات اللازمة ، و التى قد تساعد على وضع تشخيص و جلسات علاجية مقترحة .

•تساهم أدوات و تقنيات الذكاء الاصطناعي في تحسين كفاءة الممارسات العلاجية من خلال تمكين المختصين فى مجال اضطرابات التواصل من تخصيص وقت أكبر للمشاركة مع الحالات؛ فيعمل على توفير أدوات متقدمة للكشف المبكر دون التقيد بالعوائق الجغرافية ويقوم بتوثيق المعلومات الخاصة بكل حالة.

و رغم التطورات التكنولوجية الذكية، يظل دور اختصاصي علاج اضطرابات اللغة في التشخيص والعلاج والتأهيل لا غنى عنه؛ فهو صاحب القرار النهائي في التشخيص و العلاج.

الكلمات المفتاحية: الذكاء الاصطناعي ، تطبيقات الذكاء الإصطناعي، اضطرابات اللغة و التواصل