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Artificial intelligence in assessment and intervention of speech and language disorders: A literature review

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ABSTRACT

Artificial intelligence (AI) is a broad term that refers to the use of computers to replicate intelligent behavior with minimal human intervention. AI is rapidly transforming various sectors, including speech and language pathology, by offering innovative solutions to enhance therapeutic practices and client outcomes. Its application in speech and language pathology spans several domains, including medical diagnosis, therapeutic planning, and rehabilitation, utilizing tools such as machine learning and deep learning to enhance data analysis and pattern recognition. The primary aim of this study is to provide resources for speech and language pathologists on the topic of artificial intelligence by presenting research findings on the assessment and intervention of speech and language disorders using AI. Accordingly, AI studies in speech and language pathology found in the literature were included. The results of these studies were summarized, and information was provided on the use of AI in assessing and treating speech and language disorders, including swallowing disorders, voice disorders, acquired language disorders, motor and speech sound disorders, cleft palate speech, and developmental language disorder. Existing literature acknowledges and supports the growing popularity of AI and AI-based algorithms in speech and language pathology. Although the current evidence remains insufficient and concerns about ethics and implementation persist, advancing technology offers promise for applying AI in this field.

Keywords: Artificial intelligence, speech and language pathology, speech and language pathologist, voice disorders, speech disorders

Artificial intelligence (AI) is a broad term that refers to the use of computers to replicate intelligent behavior with minimal human intervention [1]. It is commonly regarded to have begun with the development of robots. Officially established as a field in 1956, artificial intelligence involves the science and engineering of creating intelligent machines. AI is applied in various areas, including medical diagnosis, medical statistics, and human biology. It is also incorporated into rehabilitation practices by various healthcare professionals, including social workers, occupational therapists, audiologists, nurses, and speech and language pathologists (SLPs) [2]. With rapid advances in technology, AI has established itself as a transformative force in various fields, including medical imaging and diagnostics. Through algorithms such as machine learning and deep learning, it has the potential to analyze complex data, identify patterns, and deliver diagnostic and prognostic insights that exceed human capabilities in terms of both speed and accuracy [3, 4].

Artificial intelligence is posited to significantly

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augment clinical practices within speech-language pathology by developing innovative tools to enhance client health and optimize therapeutic outcomes. As technological advancements progress rapidly, SLPs must develop a comprehensive understanding of artificial intelligence clinical tools, acknowledge their inherent limitations, and employ them judiciously in clinical practice as they evolve [5].

This traditional review aims to present research on the role, significance, and applications of AI in speech and language pathology. It explores how AI is utilized in various subtypes of speech and language disorders. The review has been conducted through a comprehensive examination of current articles in the literature. The data collection process began by identifying the following keywords: artificial intelligence in speech and language disorders, artificial intelligence in speech and language therapy, artificial intelligence in speech and language assessment, advantages of artificial intelligence for speech and language therapists, disadvantages of artificial intelligence for speech and language therapists, and review. These keywords were entered into the Google search engine, and related publications were examined by reviewing American Speech-Hearing Association (ASHA), ResearchGate, Google Scholar, YÖK Academic, PubMed, and Anadolu University Library databases. National and international studies conducted between 2009 and 2025 were included in the study, whereas studies conducted before 2009 were excluded.

ARTIFICIAL INTELLIGENCE IN SPEECH AND LANGUAGE PATHOLOGY

The ASHA evaluated the advantages of AI for SLPs, categorizing the findings into four primary domains [6]. Firstly, the assessment revealed that documentation and reporting—essential components for tracking and monitoring therapeutic outcomes—can be significantly streamlined by implementing various AI algorithms and technologies. This improvement enables pathologists to allocate more time to client interactions during therapy sessions, thereby enhancing overall productivity. Secondly, the investigation underscored the utility of AI within advanced assistive technologies specifically designed to aid individuals with communicative and cognitive disorders. Thirdly, the findings indicated that SLPs have the capacity to incorporate objective and validated AI tools within clinical examinations and evaluations. For instance, a simple picture identification app on a smartphone can be used to assess remote language and speech skills. Lastly, the study highlighted that these technological advancements could enhance diagnostic and therapeutic processes, tailoring them to fit the genetic, behavioral, social, cultural, and economic profiles of patients, while also considering their individual responses to interventions.

A recent study confirmed that AI-based tools reduce the workload of SLPs and provide various conveniences to enhance their productivity [7]. Speech-to-text translation programs and automated report preparation processes have been shown to decrease administrative burdens, allowing SLPs to spend more time with their clients. Proper session preparation and planning enable the creation of therapy materials tailored to each client's needs, making therapies more effective and focused. These tools help SLPs utilize their time more efficiently and significantly support their professional processes. Furthermore, SLPs view the use of AI with a mix of optimism and caution. In a survey on the topic, pathologists indicated that they found AI tools particularly useful for diagnosis and treatment planning (50%) and rehabilitation (25%). However, only a small percentage (14.8%) believed that AI could replace professional services. Overall, they believe that AI will revolutionize the field without negatively affecting employment. Many pathologists also reported that they frequently use platforms such as ChatGPT [8].

Although SLPs have various opinions on the use of AI, it is preferred in many speech-language disorders, including swallowing disorders, voice disorders, acquired language disorders, motor and speech sound disorders, cleft palate speech, and developmental language disorder. The following subheadings include studies on the use of AI in assessment and therapy processes regarding these disorders.

AI in Swallowing Disorders

In the field of speech and language pathology, several studies have utilized AI in therapy and assessment processes, particularly concerning swallowing disorders. One study focused on the use of AI-supported video games for swallowing rehabilitation. These games exhibited a notable enhancement in swallowing

function among patients suffering from dysphagia after a stroke. Additionally, they increased oral intake and boosted patients' self-confidence by visualizing their movements during exercises. Moreover, the integration of AI and video games enhanced nutritional status by reducing complications such as weight loss and fatigue, ultimately improving quality of life. In the initial stages, rapid improvements were noted in the group using AI-supported video games. However, over the long term, both interventions resulted in similar outcomes [9]. In a similar study, surface electromyography biofeedback (sEMG-BF) combined with gaming was found to significantly enhance swallowing function in individuals with post-stroke dysphagia [10]. AI and AI-assisted tools have been effectively utilized not only in dysphagia therapy but also in its assessment. The results of a study aimed at automating the diagnosis of dysphagia through the development of an artificial intelligence-based web application, which analyzes Videofluoroscopic Swallowing Study (VFSS) data and offers clinicians more accurate evaluation opportunities, demonstrated that the YOLOv7 algorithm used in the study achieved high accuracy rates in dysphagia classification. This system can provide significant support to clinicians in patient care management [11]. A recent study aimed to evaluate the efficacy of using ultrasound as a quantitative method for assessing the kinematics of the hyoid bone during swallowing, with the goal of predicting Penetration-Aspiration Scale (PAS) scores. The researchers further explored the capabilities of a machine learning (ML) algorithm in forecasting PAS outcomes. The findings revealed that manual ultrasound measurements, when employed in isolation, did not provide a sufficiently accurate prediction of PAS scores. In contrast, the ML algorithm demonstrated a notable level of precision in predicting these results, suggesting its potential as a more reliable tool for clinical assessment in this context [12]. Sanjeevi *et al*. [13] compiled research on the use of AI techniques in VFSS analysis. They highlighted advancements in several areas, including the analysis of swallowing phases, segmentation of anatomical components, and the detection of penetration-aspiration events. However, the authors noted significant limitations in the research within this field, such as the fact that AI models often operate under specific assumptions, the lack of transparency and interpretability, and the absence of comprehensive and publicly accessible datasets [13]. Kim *et al*. [14] utilized convolutional neural networks (CNNs) to determine the presence of aspiration with high accuracy in 190 participants with dysphagia. Similarly, Iida *et al*. [15] used CNNs to detect aspiration in nearly 18,000 images, demonstrating that deep learning has the potential to detect aspiration with precision. Bandini *et al*. [16] studied specific time points in the pharyngeal phase, focusing on the moments when the bolus crosses the mandible and when the upper esophageal sphincter closes. CNN-based methods demonstrated high accuracy in detecting these moment measurements [16]. Hsiao *et al*. [17] developed a CNN-based algorithm for the automatic tracking and kinematic analysis of hyoid bone motion during swallowing. This algorithm calculates the precise positioning, direction, and velocity of the hyoid bone relative to the anatomical axis. Consequently, clinicians can conduct assessments more objectively and efficiently [17]. Nakamori *et al*. [18] demonstrated that assessing swallow sounds in patients with amyotrophic lateral sclerosis (ALS) using an electronic stethoscope and AI analysis showed a significant correlation with established swallow assessment parameters. They suggested that this method could serve as a new assessment tool suitable for home and remote medical care [18]. Despite this cutting-edge development in dysphagia management, there are also some limitations. Girardi *et al*. [19] emphasized that AI-assisted analyses have the potential to increase accuracy, speed, and efficiency in dysphagia diagnosis and treatment, but require large data sets and interdisciplinary collaborations.

AI in Voice Disorders

Another area where AI is commonly utilized in speech and language pathology is the management of voice disorders. A comprehensive review of the existing literature suggests that AI technologies are primarily used for diagnosing various voice disorders and for distinguishing between dysphonic and non-dysphonic voices. However, there are relatively few studies that classify the types of voice disorders or evaluate them using the GRBAS scale [20]. Although it was emphasized that AI technology has significant potential in detecting voice pathologies, it was indicated that clinical validation studies, data standardization, and consistent reporting methods are necessary to advance

research in this field. Kojima *et al*. [21] aimed to develop standardized methods for directly assessing pathological voice quality using one-dimensional convolutional neural network (1D-CNN) models. The findings revealed that these models were comparable in reliability to expert assessments using the GRBAS scale. In another study, a system was presented that can distinguish between healthy and pathological voices using machine learning algorithms and perform reliable voice disorder detection, operating entirely on a mobile device [22]. A similar study aimed to develop a reliable mobile health system that can intelligently classify healthy and pathological voices using machine learning algorithms and was shown to have the highest accuracy in detecting voice disorders [23]. In their study, Constantini *et al*. [24] analyzed voice properties for the early diagnosis of Parkinson's disease (PD) using ML techniques and identified voice biomarkers that could differentiate between healthy individuals, PD patients diagnosed early and not taking medication, and PD patients in the intermediate-advanced stage receiving L-Dopa treatment. In their study, Hegde *et al*. [25] examined various databases, feature extraction methods, and machine learning approaches focused on the automatic detection of voice disorders. They emphasized that these techniques can significantly enhance patients' quality of life by enabling the early identification of voice disorders [25]. Al-Hussain *et al*. [26] evaluated the effectiveness of ML algorithms in screening and diagnosing voice disorders and found that ML-based systems achieved high accuracy (93%), sensitivity (96%), and specificity (93%). In a study focused on detecting various vocal fold disorders through the recognition of pathological voice types using artificial intelligence, voice samples were collected from 189 individuals with normal voices and 552 individuals with voice disorders. These disorders included vocal atrophy, unilateral vocal fold paralysis, organic vocal fold lesions, and adductor spasmodic dysphonia. A convolutional neural network model was developed, achieving a sensitivity of 0.66, a specificity of 0.91, and an overall accuracy of 66.9% in distinguishing between normal voices and the mentioned disorders. Comparing the accuracy with the judgments of voice specialists, the overall accuracy rates were 60.1% and 56.1% for the two laryngologists and 51.4% and 43.2% for two general otolaryngologists [27]. Kim *et al*. [28] developed a model that distinguishes between voice samples of healthy individuals, patients with laryngeal cancer, and those with other laryngeal diseases using artificial intelligence. They tested various Mel-Frequency Cepstral Coefficient (MFCC) transformation methods and machine learning techniques, achieving an accuracy rate of 85% to 97% in identifying laryngeal diseases compared to healthy voices [28]. Similarly, another study examined the role of ML techniques in the diagnosis and monitoring of voice disorders and found that PD was the most frequently studied disease [29]. While the findings reveal a growing interest in ML-based voice analysis studies, the datasets used are limited and unbalanced. Research has focused on diagnosis, but insufficient attention has been paid to monitoring the disease process. The study emphasizes that these shortcomings should be addressed in future research.

AI in Acquired Language Disorders

Artificial intelligence is increasingly being utilized in neurological disorders such as aphasia and dementia. One notable study focused on an AI program that translates text into images for patients with aphasia. In this study, 189 out of 200 target texts (94.5%) were successfully visualized to convey the key concepts. However, many of the visualizations had aesthetic flaws, which could impact their effectiveness. Nouns were visualized with the highest efficiency and accuracy, followed by verbs, while visualizing complete sentences proved to be more challenging. Consequently, the ability of AI to quickly generate low-cost, high-quality images is considered a significant advancement in the assessment and treatment of aphasia [30]. Another comprehensive review study on aphasia examined different methods for an automatic speech assessment system that classifies the severity of aphasia [31]. Both AI and deep learning models were used for classification. CNN, recurrent neural networks, and hybrid models were reported to yield better results than traditional algorithms. In a systematic review of the use of AI in assessing speech and language skills to predict cognitive decline in Alzheimer's disease, promising results were reported in almost all 51 studies; however, few have been implemented in clinical research or practice [32].

Grasemann *et al*. [33] developed a neural network model called BiLex, which includes two separate phonetic maps and a common semantic map, to predict

the development of language skills in bilingual aphasia patients. The study revealed that the BiLex model was able to successfully predict the development of language skills in the treated language but had lower prediction accuracy in the untreated language and tended to underestimate cross-linguistic generalization [33]. Pustina *et al*. [34] and Kristinsson *et al*. [35] investigated the predictive power of neuroimaging data for aphasia symptoms and severity, finding that different neural networks in AI yielded successful results. Both studies showed that multimodal imaging data outperformed predictions based on a single modality and that different language abilities were best predicted with different neural predictors. These studies reveal that ML approaches can contribute to clinical decision-making processes in aphasia assessment; however, clinical validation of the models has not yet been completed. Themistocleous *et al*. [36] investigated the power of acoustic and linguistic features of connected speech to predict patients with primary progressive aphasia (PPA) and compared different AI networks. The models were generally highly accurate, especially for PPA patients with reduced verbal fluency and fluency difficulties, but less accurate in discriminating PPA patients with comprehension-related disorders. Additionally, the study compared the accuracy of the AI models with the classification performance of three less-experienced speech-language pathologists. The results showed that the AI models achieved a higher overall accuracy. These findings highlight the potential of AI to assist in clinical decision-making, indicating that it may surpass pathologists in specific situations [36]. A systematic review on this topic found that AI is primarily used for diagnosis and classification in aphasia rehabilitation. However, there is no evidence suggesting its integration into augmentative and alternative communication (AAC) devices or in direct therapy applications. Some studies have utilized AI to support aphasia therapy, while others have evaluated its effectiveness in modeling word production processes or classifying paraphasic errors [37].

AI in Motor Speech and Speech Sound Disorders

In the examination of AI applications for assessing and treating speech disorders, significant scholarly investigations have focused on both motor speech and speech sound disorders. Researchers have proposed a new language-based human-computer interaction tool, as well as a gamified AI-driven tool, specifically designed for individuals with motor speech disorders [38]. In addition, Frieg *et al*. [39] developed a digital training system for individuals with dysarthria. Another similar study evaluated the accuracy and therapeutic effect of an iPad-based speech therapy application with automatic speech recognition (ASR) software for individuals with apraxia of speech and aphasia after stroke and found that ASR agreed with expert assessment 80% of the time. Participants showed lasting improvements in word production accuracy with ASR-based feedback [40]. Ballard *et al*. [41] conducted a feasibility study of a tablet-based automated feedback tool for individuals with apraxia. In a review study, it was found that AI-based automated speech therapy tools developed for individuals with speech sound disorders offer potential benefits, but there is limited evidence of their effectiveness, and they cannot fully replace speech-language pathologists; nevertheless, it was emphasized that some time-consuming tasks of speech pathologists can be supported by artificial intelligence [42]. Another study examines how AI systems, specifically Voiceitt, can enhance AAC technologies for individuals with severe speech disorders. Voiceitt is an intelligent software application that transforms unintelligible speech into clear, understandable communication in real-time. This technology enables individuals with motor or cognitive disabilities to communicate effectively with caregivers, family members, healthcare professionals, and the broader society. Facilitating communication promotes greater participation and allows people with disabilities to live more independently [43].

AI in Cleft Palate Speech

Another area of focus concerning speech sound disorders is cleft palate speech. A systematic review by Zhang *et al*. [44] evaluated the effectiveness of AI algorithms in detecting persistent hypernasal speech that requires revision following primary repair surgery in individuals with cleft palate. The study found that these algorithms could detect hypernasality quickly and independently, achieving a high level of agreement with speech-language pathologists. These findings suggest that AI can enhance clinicians' capabilities and serve as a valuable complement to existing gold-standard practices.

AI in Developmental Language Disorder

Language disorders, particularly Developmental Language Disorder (DLD), represent significant domains in which AI is increasingly employed within speech-language pathology. A recent study focused on the early diagnosis of DLD, addressing the limitations of traditional risk factors in younger age groups and bilingual children. Researchers have developed a web-based tool called MARS, which has shown potential in distinguishing between children with and without DLD by analyzing rhythmic vocal production [45]. Studies have shown that AI-based communication devices enhance individuals' expressive speech by providing real-time feedback through natural language processing algorithms. Additionally, AI-supported interactive games and screening tools significantly contribute to language development, encourage social interaction, and facilitate the early detection of developmental disabilities. In ElHennawy's study [46], the roles of AI and ML in assessing and treating communication disorders were discussed, highlighting the importance of early and accurate diagnosis. The study demonstrated that AI can rapidly and accurately analyze large datasets to create tailored treatment plans for clients. Furthermore, it provides SLPs with various tools to enhance therapy processes [46].

Disadvantages, Limitations, and Barriers of AI in Speech and Language Pathology

Besides the advantages mentioned above, AI also presents some challenges and disadvantages in the field of speech and language pathology. Although several studies have reported positive outcomes for AI, significant limitations exist. For instance, researchers have highlighted that AI models used in swallowing disorders often operate under specific assumptions and lack transparency and interpretability. Concurrently, the absence of comprehensive and publicly available datasets has been identified as a substantial shortcoming [13]. Moreover, a study on voice disorders revealed that the diagnostic accuracy between AI and voice experts did not exceed 60.1%. This accuracy level is relatively low for critically essential conditions such as voice disorders [27]. Additionally, the researchers pointed out the existence of limited and unstable datasets in AI [29]. Another study on aphasia found that the AI program that converted text to images successfully transformed 189 out of 200 target words into images. Yet, the researchers noted that these images had aesthetic flaws that could impact their effectiveness. At the same time, while nouns and verbs can be illustrated with higher proficiency through the AI program, visualizing complete sentences remains quite challenging [30]. Although studies on the assessment of aphasia highlight the importance of AI support in clinical decision-making, research into the clinical validity of these models remains incomplete [34, 35]. Researchers in the field of motor speech disorders also emphasize the lack of sufficient evidence [42].

In a study by Suh *et al*. [7], it was indicated that SLPs face several key challenges, including keeping up with technological advancements, time constraints, resistance to technology, privacy and ethical concerns, job security concerns, and broader ethical issues such as artistic expression and intellectual property rights. In addition, Koenecke *et al*. [47] emphasized that ethical issues need to be systematically addressed in the clinical use of AI. These issues are particularly related to biases in datasets and algorithms, such as unfair representation. For instance, automatic speech recognition systems demonstrate lower accuracy for African American speakers of English compared to speakers of General American English, and this difference is particularly pronounced in children [47]. Since AI systems are often trained with real-world data, they can learn and reinforce data imbalances related to underrepresented groups; this is referred to as "algorithmic bias" and can lead to the exclusion or misclassification of individuals with age, gender, language differences, voice characteristics, or neurological disorders in SLP interventions [48]. Moreover, Kanwah *et al*. [49] reported that the operation of fully automated AI-based tools without therapist, caregiver, or parental involvement raises ethical concerns such as data bias, privacy violations, and the potential to replace speech-language pathologists, especially in speech sound disorders. In addition, concerns regarding the data privacy and security of patient information complicate research processes and hinder the integration of AI into clinical practice [50]. Furthermore, a recent study by Birol *et al*. [51], which aimed to explore the potential of ChatGPT, found that ChatGPT struggled to generate materials specific to Turkish; its responses and generation lacked sufficient depth, particularly regarding specialized terminology and culturally relevant

stimuli. Additionally, another limitation of ChatGPT is that it often requires the assistance of an experienced SLP to address its shortcomings. This study also suggests that tackling the ethical concerns, risks, and practical challenges associated with integrating AI into clinical practice is crucial. AI systems require large amounts of patient data, which raises issues related to data storage, sharing, protection, and patient privacy. Moreover, these systems can produce misdiagnoses, particularly in cases that fall outside their training data. Overreliance on AI tools may also diminish clinicians' critical thinking skills. The high costs of developing and maintaining AI could limit accessibility for some healthcare providers. To address these concerns, proper training for clinicians is essential, along with establishing clear ethical guidelines and standards to govern the use of AI in healthcare [51].

CONCLUSION

The increasing popularity of AI and AI-based algorithms in speech and language pathology has been acknowledged and backed by existing literature. AI is now being used not only for assessments but also in therapies, monitoring, and reporting. Although the current evidence remains insufficient and there are ongoing concerns about ethics and implementation, the advancement of technology offers promise for the application of AI in speech and language pathology. Future studies will enhance speech-language pathologists' understanding and awareness of AI, contribute to a more substantial evidence base, and lead to improvements in clinical practice.

Ethical Statement

Ethical approval is not required for this study. There are no human or animal elements in the study. This review was carried out by a brief literature screening.

Authors' Contribution

Study Conception: EB, BÖ; Study Design: BÖ, EB; Supervision: EB, BÖ, SSB; Funding: N/A; Materials: N/A; Data Collection and/or Processing: BÖ; Statistical Analysis and/or Data Interpretation: EB, BÖ, SSB; Literature Review: EB, BÖ; Manuscript Preparation: EB, BÖ, SSB; and Critical Review: EB, BÖ, SSB.

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