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The Role of AI in Enhancing Expressive Language in Intellectually Disabled Children

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The Role of AI in Enhancing Expressive Language in Intellectually Disabled Children

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Abstract

AI can optimize an intellectually disabled child's language-learning environment to ensure fullest potential, Research shows home environment predicts language development, but creating enriching environment can be challenging. AI technologies can help. Recent advances in AI show promising results in assisting children with disabilities to develop strong language skills. By utilizing natural language processing and machine learning algorithms, AI can provide personalized and interactive language learning experiences for intellectually disabled children. The SpeakDif project is emblematic of the potential for AI to revolutionize language learning for children with disabilities. Studies have shown that improved communication abilities can lead to increased self-esteem and social integration for children with disabilities. AI has the potential to revolutionize the field of language acquisition for intellectually disabled children, empowering them to achieve their fullest potential and participate more fully in the world around them.

Recommendations:

1. Enhance Home Learning Environments.
2. Implement AI in Educational Settings
3. Promote Awareness and Training
4. Support Research and Development

Keywords: Artificial intelligence, expressive language, predictive modeling, language interventions, intellectually disabled children.

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دور الذكاء الاصطناعي في تعزيز اللغة التعبيرية لدى الأطفال ذوي الإعاقات الفكرية

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مستخلـــص

يستطيع الذكاء الاصطناعي (AI) تحسين بيئة تعلم اللغة لدى الأطفال ذوي الإعاقات الفكرية لضمان تحقيق أقصى إمكاناتهم. وتشير الأبحاث إلى أن البيئة المنزلية تؤثر على تطور اللغة، ولكن إنشاء بيئة غنية بالمحفزات قد يكون تحديًا. يمكن لتقنيات الذكاء الاصطناعي المساعدة في هذا الصدد. أظهرت التقدمات الحديثة في مجال الذكاء الاصطناعي نتائج واعدة في مساعدة الأطفال ذوي الإعاقات على تطوير مهارات لغوية قوية. من خلال استخدام معالجة اللغة الطبيعية وخوارزميات التعلم الآلي، يمكن للذكاء الاصطناعي توفير تجارب تعلم لغوية شخصية وتفاعلية للأطفال ذوي الإعاقات الفكرية. يعتبر مشروع "SpeakDif" مثالاً نموذجيًا على إمكانات الذكاء الاصطناعي في إحداث ثورة في تعلم اللغة للأطفال ذوو الإعاقات. وقد أظهرت الدراسات أن تحسين القدرات التواصلية يمكن أن يؤدي إلى زيادة تقدير الذات والتكامل الاجتماعي للأطفال ذوي الإعاقات. ويحمل الذكاء الاصطناعي إمكانات هائلة لإحداث ثورة في مجال اكتساب اللغة للأطفال ذوي الإعاقات الفكرية، مما يمكنهم من تحقيق أقصى إمكاناتهم والمشاركة بشكل أكبر في العالم من حولهم.

التوصيات:

1. تعزيز بيئات التعلم في المنزل
2. تنفيذ الذكاء الاصطناعي في المؤسسات التعليمية
3. تعزيز الوعي والتدريب
4. دعم البحث والتطوير

الكلمات المفتاحية: الذكاء الاصطناعي، اللغة التعبيرية، النمذجة التنبؤية، تدخلات اللغة، الأطفال ذوو الإعاقات الفكرية

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1. Introduction

Artificial intelligence (AI) is primarily used to enhance the abilities of typically developing children and intellectually gifted children, rather than those who are intellectually disabled. It is essential to consider the expressiveness of children with intellectual disabilities and harness the power of AI to enhance their language competence. We seek to bridge the gap in AI technology and ensure that no child is left behind, regardless of their cognitive abilities. Our goal is to elevate AI to a new level of understanding and responsiveness, where it is intelligent, empathetic, and inclusive. Through a multidisciplinary approach, we aim to provide an empowering environment for children with intellectual disabilities to access and benefit from AI. Every child deserves the opportunity to thrive, and together, we can ensure that AI becomes a tool for empowerment, enabling every child to communicate, learn, and grow to their fullest potential, [figure1].

1.1. Background and Rationale

Given various children's preferences and volition affinities, how can we identify an intervention that fits both the specific child's and the robot's abilities? In order to provide each child with an intervention tailored to his/her preferences or volition affinities with the highest probability of being effective, the project will first develop some criteria to identify-sidedness markers (Barua et al, 2022, Hopcan et al, 2023). These sidedness markers should be identified and quantified on-line, like in a continuous manner, and be used to rank in real time a set of pre-existing or newly developed interaction scenarios. Children display their preferences or volition affinities by, inter alia, adopting specific, recurring postures or performing specific, recurring movements. During the course of the project, other criteria will be developed that can be used to further increase the set of child-specific-preferring interaction scenarios (Kaelin et al, 2021). This project will consider both the child's and the robot's present overall capabilities, as in understanding at what level the robot is a suitable interaction partner for the child and vice versa. This research and development will be carried out in the context of the Hand in Hand project. The project will address these questions, first in a non-real-time, then in a real-time manner.

(Almufareh, etal, 2023)

Accompanying behavioral detection of sidedness will be performed and prospective videos recorded and analyzed to validate these markers. The project will first develop the ad-hoc abilities for detecting sidedness based on the DARWIN open software architecture for cognitive robot development. Subsequently, the work will be carried out by integrating these abilities into the NAO robot and the mobile robot platform. The Hand in Hand project targets the improvement of the emotional state of children with intellectual disability in the most natural and efficient way, by allowing them to play and establish an affective relationship with a robot that is fully integrated in the child's world, acting as a peer. The main project's idea is to enhance each child's development of expressive language by motivating each child to tell the robot his/her own individually most cherished fantasy narrative. The project will develop a set of robotic-based interventions with the ultimate goal of enhancing the emotional state of each child in the short term. This will be achieved by developing an individual connection between child and robot at an affective, cognitive and social level, acting as the child's 'peer', within the child's intelligence and disability parameters. In the longer term, the child's development of expressive language will be addressed which, in a child with intellectual disability, usually represents the most complex task. This long-term goal is crucial for the achievement of the project's overall goal, which is to improve the quality of life and emotional well-being of children with intellectual disability through the assistance of robotic-based interventions tailored to the specific needs and capabilities of each individual child.

1.2. Research Aim and Objectives

1. To describe the current state of expressive language in intellectually disabled children and adolescents and the factors that influence it.
2. To explore and describe how AI technology can be utilized and adapted to enhance expressive language in these children and adolescents.
3. To develop guidelines to help professionals (speech and language therapists, special education teachers) choose and utilize AI tools to enhance expressive language in their clients, and also collaborate with AI experts to develop new AI tools. These guidelines should be based on feedback from research participants and the experts in the multidisciplinary team and should undergo several cycles of empirical testing and refinement.

The aim of this research is to harness AI technology to bridge the expressive language gap experienced by many intellectually disabled children. When the gap is significantly reduced, these children will be better able to interact

with others and improve their social skills development. The research will be conducted with the following three specific objectives in mind.

2. Understanding Expressive Language in Intellectually Disabled Children

It is crucial to foster the development of expressive language in children with intellectual disabilities, as it serves not only as a means for them to convey their emotions and ideas, but also plays a pivotal role in their overall growth (Khalid et al, 2024). The ability to express oneself through language empowers children to pose inquiries and explore the world around them. Moreover, it facilitates their participation in conversations, which is vital for their social development (Torrado et al, 2020). A deficit in expressive language can lead to frustration and behavioral issues in intellectually disabled children. These children often have a restricted vocabulary, which impedes their ability to articulate their thoughts. Expressive language in intellectually disabled children is frequently hampered by difficulties in constructing coherent sentences, using a limited range of words, and grasping grammatical rules (Guo et al, 2020, Joudar et al, 2023). Furthermore, many of these children experience speech impediments that further hinder their capacity to communicate effectively (Hughes et al, 2022). Consequently, children with intellectual disabilities utilize expressive language less frequently and often encounter delays in the development of these skills (Kharbat et al, 2021).

2.1. Definition and Characteristics of Intellectual Disability

It is important to clarify that not all individuals with intellectual disabilities present the same clinical profile. In fact, there is significant variability in the level of intellectual functioning, the adaptive behaviors affected, and the etiology of the condition. This means that the majority of individuals with the diagnosis of intellectual disability do not have a uniform profile (Shahid et al, 2022). This is particularly relevant as, historically, individuals diagnosed with intellectual disability were frequently institutionalized and are still one of the most socially excluded and vulnerable groups (Khalid et al, 2024). Lower functioning individuals, especially those with additional physical or sensory impairments, are more likely to suffer from the lack of structured support and appropriate services tailored to their needs, as well as their expressive language impairments (Lian et al, 2023).

Intellectual disability is a neurodevelopmental disorder affecting around 1-3% of the general population (Ghafghazi et al, 2021). It is a condition of arrested or incomplete development of cognitive abilities, which is also

associated with limitations in adaptive and age-appropriate functioning, starting during the developmental period (Sharma and Dash2023). The term "intellectual disability" is recognized globally by international organizations such as the World Health Organization (WHO) and the United Nations (UN) (Ghafghazi et al, 2021). According to the Diagnostic and Statistical Manual of Mental Disorders (5th ed.; DSM-5), the diagnosis of intellectual disability requires deficits in intellectual functions, deficits in adaptive functioning, onset of these deficits during the developmental period, and severity that indicates the necessity of specialized support and services (Abdel et al, 2022). This recognition is important for ensuring that individuals with intellectual disabilities receive the necessary support and accommodations to lead fulfilling lives. Additionally, it serves as a framework for understanding and addressing the unique needs of this population at a global level. By acknowledging intellectual disability as a valid and important concept, we can work towards creating a more inclusive and accessible society for all individuals, regardless of their cognitive abilities. (Bhatti et al, 2023, Standen et al, 2020)

2.2. Challenges in Expressive Language Development

Percentages of children who have significant expressive language delays, even with early and consistent treatment, are rather high. Both biological and behavioral factors contribute to these high prevalence rates (Wheeler et al, 2022). On the biological side, we have concerns of genetic syndromes, maternal prenatal stresses, and perinatal insults. On the behavioral side, children with intellectual disability have their expressive language development undermined both by core intellectual delays and by specific weaknesses in grammar, core conceptual knowledge, and social-emotional behavior (Huq et al, 2024). In sum, the development of expressive language faces a perfect storm of challenges in children with intellectual disability, and it is not surprising that they struggle to learn it (Barua et al, 2022). Importantly, the high prevalence of these struggles also points to the need to find effective ways to address them.

Children with developmental intellectual disability or lower intellectual quotient are characterized by impoverished expressive language relative to their typical developing peers, and such delays have enduring negative consequences (Anagnostopoulos et al, 2020). Expressive language is formed by using words to convey an individual's thoughts, feelings, and intentions and is critical for communication and social interaction. While most children eventually acquire proficient expressive language, children with intellectual

disability often struggle throughout their lives (Huq et al, 2024). The challenges of developing expressive language arise not just from inherent intellectual delays but more from complex interactions with core conceptual development, social-emotional development, and the immediate communicative context (Kaelin et al, 2021).

3. Overview of Artificial Intelligence (AI) Technologies

Next, there is a discussion of the constraint when working with the language skills of a child with an intellectual disability. This is followed by the presentation of a framework that can be used to enhance language expression in intellectually disabled children (AlRawi and AlKahtani2022). Later sections provide an in-depth discussion of the different technologies and conclude with a futuristic view.

This chapter presents technologies that come under the umbrella of AI that have the potential to enhance the expressive language skills of intellectually disabled children. The chapter first provides a brief outline of the different approaches and technologies that can enhance expressive language. These are the Speech-to-Text (STT) technology, the Natural Language Generation (NLG) technologies, the Recurrent Neural Networks (RNN), and the Long Short-Term Memory (LSTM) models (Syeda, 2024, Volkov, 2024, Goldman et al, 2023).

In recent years, rapid advancements in artificial intelligence (AI) have led to many applications that increasingly surround us, making our lives easier (Xu et al, 2021). These applications range from the seemingly simple and common use of AI in online search engines to more complex uses of AI in driverless cars or AI employed in robotic assistants (Adamssen, 2020). AI is essentially the simulation of human intelligence processes by machines. What is particularly notable is the potential for AI to enhance human abilities, especially when some form of human disability is involved (Yang et al, 2021).

3.1. Machine Learning and Natural Language Processing

The combination of Natural Language Processing (NLP) and Machine Learning (ML) forms the core of many AI solutions capable of supporting and enhancing human language. The challenges that understanding, generating, or enhancing human language bring about create specialized learning experiences for children (Sharifani et al, 2022). Despite the potential impact, little focus is currently given to the application of NLP technologies on the language development of children, particularly children with

intellectual disabilities (Norrie et al, 2024). In addition, there are considerable knowledge gaps that manifest in the assumptions that are made and the data sparsity that is faced when designing such technologies (Drenkow et al, 2021).

Using these advanced AI technologies to enhance expressive language in intellectually disabled children has the potential to not only help them improve their language capabilities but also build their confidence and self-esteem (Mehta et al, 2023). It is important that these children feel understood and that their communication is valued in order to create a positive learning experience. With the help of AI, this learning experience can be customized for each child to better suit their individual needs, making it easier for them to progress and develop their language skills (Abdel et al, 2022). This can be done by developing AI tools that are capable of understanding the unique challenges that intellectually disabled children face when communicating and then helping them overcome these challenges in a supportive and non-judgmental way (Norrie et al, 2024).

Artificial intelligence (AI) is made possible thanks to the powerful idea humans have to recreate their own intelligence in machines. Machine learning, a core AI technology, provides machinery the ability to learn and improve from experience (Haidine et al, 2021). By bringing together another transformative technology, which is natural language processing, machine learning harnesses the power of words and enables tools that can understand and produce human language. Currently, expressive language is highly enhanced using AI-based chat tools, dialogue agents, or learning companions (Hofmann & Müller. 2021). Developers at every corner of the world design models and create open-source tools to contribute to a human-like technology that understands and speaks every language, like the ancient sci-fi dreams come true (Chobanian et al, 2022).

4. Applications of AI in Education

The collaborative and creative skills can be developed through the co-creative intelligence framework that employs well-defined prompts. However, the technology is often not sufficient for education technology to be utilized in low resource settings. In spite of the existing challenges, AI has the potential to transform education, not just for typically developing students, but it can also optimize and personalize the educational paths of the disabled as well as those who struggle due to intellectual or socio-economic barriers (Aggarwal, 2023).

AI has been used to personalize educational paths. The knowledge tracing model based on deep learning is one way to track the knowledge of students and has been employed within adaptive learning platforms (Kabudi et al, 2021). Admittedly, the current level of personalization is far from ideal, the collective knowledge of the students can be employed to enhance personalization (Lim et al, 2021).

The power of artificial intelligence can be employed in various aspects of education, for typically developing students as well as those struggling due to any sort of intellectual, physical, or socio-economic barriers (Barua et al, 2022). Some of the intelligent tutoring systems (ITS) have existed for more than two decades, promoting learning via one-to-one tutoring and augmenting typical classroom instruction (Banawan et al, 2023). With the advancement in AI, the current crop of ITS systems is much more sophisticated. For instance, the tutors in the recent ITS are capable of speech recognition, computer vision, affect recognition, and natural language processing. Furthermore, the newer generation of ITS can adapt to the affective and cognitive state of a student, thereby providing necessary support to an agitated or bored student. In addition to the ITS, there are AI systems that facilitate grading of open-ended questions and aid in the creation of educational software. The deficiencies of such software can also be pointed out using some of the advanced AI systems (Zhai et al, 2021, Kabudi et al, 2021).

4.1. Personalized Learning Platforms

Even the existing tutoring systems are not able to provide a wide range of feedback to children with various learning challenges, including different intellectual disabilities. New AI technologies, combined with biomedical informatics and education informatics, can change and enhance all that (Garg and Sharma, 2020). Within this approach, artificial intelligence should be utilized to build culminating integration architecture that is able to utilize all available knowledge about how to generate feedback and tutoring in the most effective way for each individual student. The architecture should constantly adapt and enhance all components—learning models, data models, ontologies, and knowledge components, as well as interface models and feedback models (Ahuja et al, 2022). The AI enhancement should be done regarding the ability of the system stacked to interact with the student in various modalities, including expressive language but also other modalities, as is necessary to assist and assess the student's knowledge and generate student's progress (Zhai et al, 2021). Through AI, the system can be designed

to understand the unique needs of each student and provide personalized feedback and tutoring in a way that is most effective for their individual learning style. This approach has the potential to revolutionize the way we educate and support students with diverse learning challenges, ensuring that no child is left behind in their educational journey (Chen et al, 2020). With the integration of AI into education, the possibilities for personalized learning and support are endless, and the impact on students with intellectual disabilities could be truly transformative (Yuskovych-Zhukovska et al, 2022). By harnessing the power of AI and integrating it into our educational systems, we can create an inclusive and supportive environment for all students, providing them with the tools and resources they need to thrive academically and beyond (Eden et al, 2024).

AI can help build adaptive and reflective systems, tools, and protocols that can be used to amplify and expand personalized learning for every child. Currently, there are a number of such platforms. For example, in the Project LISTEN (Literacy Innovation that Speech Technology Engages), the Reading Tutor is a computer-based reading system in which a child reads to an automated listener (Dieterle et al, 2024). Sphinx-II, a Carnegie Mellon-developed speech recognizer, is used to score the child's reading. The system "listens" using speech recognition and provides tutoring in the form of an animated agent on the computer screen. The tutoring system responds to the child mainly by recognizing the child's speech and translating it into text (Xia et al, 2022). Adapting AI in learning environments allows for the creation of customized learning experiences, adjusting to the individual unique needs of each student. This in turn enhances the overall effectiveness of the learning process and promotes a more engaging and successful educational journey for students of all ages (Chen et al, 2023). By leveraging AI, educators and parents can better support students in their cognitive development, providing them with the tools and resources they need to thrive in their educational pursuits. Overall, AI has the potential to revolutionize the way we approach education, making it more accessible, inclusive, and tailored to the specific needs and abilities of each learner (Xia et al, 2022).

4.2. Speech Recognition and Synthesis Systems

Using AI to enhance these systems, including flexibility in phrases and sentences, producing natural intonation and stress patterns, and providing real-time corrections, can substantially reduce the burden on the user, thus providing potential solutions capable of serving a broader user group (Judijanto et al, 2022). There is growing interest and activity in developing

speech recognition systems for specific user groups or specific applications that cater for some of the different abilities and characteristics of users who require ACC (Onesi-Ozigagun et al, 2024). The aim of this article is to outline the design aspects of speech recognition systems used by people who require ACC (Gupta & Chen, 2022).

Large-vocabulary speech recognition is significantly more difficult for disabled persons who rely on speech synthesizers because they use a limited set of phrases and sentences to produce speech, which in turn limits the user's capability to produce novel speech for the machine. This is often a conscious decision by the designers of augmentative and alternative communication (ACC) devices because it reduces the workload of the user, decreases the time to select speech, and can provide more intelligible speech (Chen et al, 2023). However, the choice of system suggests a tradeoff between efficiency and flexibility. In fact, for any given task, the flexibility can be increased up to a point where performance becomes too burdensome for the user to endure (Garg and Sharma, 2020).

Despite the enormous importance of speech and language for humans and the large number of people with speech and language impairments, the area of assistive technologies to support expressive language is generally overlooked. Speaking is much more than just producing sound. It involves complex coordination of muscles and airflow (Xia et al, 2022, Onesi-Ozigagun et al, 2024). The process of converting sound into words also places considerable effort on the listener who must interpret the meaning of the sound. Most existing speech-to-text systems are developed for the general population who wants to convert spoken words into text for convenience (Gupta & Chen, 2022).

5. Current Approaches to Enhancing Expressive Language in Intellectually Disabled Children

Formalize expressive language work into structured intervention or lessons, breaking it down into manageable parts. Use visual supports like picture cards, written words, or visual schedule to help comprehension. Play and exploration in a relaxed, child-led setting can enhance expressive language. Create a rich expressive language environment. Implement cross-disciplinary teams, including speech and language therapists, teachers, and parents, to support and promote expressive language. Engage parents for additional support.

5.1. Human-Driven Therapeutic Interventions

To assuage these worries, researchers and developers have to be mindful in the creation and implementation of AI tools for expressive language development. The ultimate goal is to use AI as a tool that works with people, not a replacement for people. The current workload of AI in the field of speech therapy is encouraging. It can help in checking the child's progress, carrying out practice sessions, and also freeing up human therapists to establish the emotional connection and bond with the child, as well as to focus on more important aspects of the therapy. At the same time, the child can benefit from the inquisitiveness of interacting with a new 'person' (the AI) to maintain their interest in learning (Judijanto et al, 2022, Onesi-Ozigagun et al, 2024).

Children with intellectual disabilities require speech therapy to improve and develop their expressive language. Human-driven therapeutic interventions from experienced therapists have been proven to be the most effective way of accelerating the children's progress. Moreover, the emotional relationship and bond that can be established during in-person therapy sessions are essential for gaining the child's trust and maintaining their interest in learning. However, with the emergence of AI in this field, there is a shift in proportion from in-person therapy towards remotely delivered therapy. This raise concerns if the quality of speech therapy is affected and whether children receiving remote therapy are still able to develop their expressive language as effectively (Berendt et al, 2020).

5.2. Technology-Assisted Interventions

In the discussion of AI's role, potential and constraints should be considered. First, our goal should be to maximize children's expressive language, not to replace it with a different, more AI-friendly system. Second, to be truly successful, AI should support children interacting with peers, teachers, and parents. Learning to communicate with different audiences is important. Third, we should be conscious of the autonomy levels in AI operation, as minimizing the learning curve can also minimize the potential for growth. Children must be front and center in guiding the design of future AI technologies. In conclusion, technology is not going to change children with ID, but children with ID, supported by technology, can change the world for the better (Xia et al, 2022, Gupta & Chen, 2022, Judijanto et al, 2022).

Several technology-assisted interventions help children with ID express themselves. Picture exchange communication systems (PECS) and speech-generating devices are widely used. Newer technologies, such as

smartphones and tablets, have created more engaging systems. Some apps allow voice output; others use Bluetooth to connect to external devices that provide voice output. Natural language programming allows voice output with more complex sentences. AI technologies, such as facial expression recognition, can be combined with voice recognition to help children with ID understand emotion and intent and respond with appropriate language. AI can support educators in planning lessons, designing individual education plans, and assessing student performance. The responsibility to create supportive, inclusive environments is where humans excel, and we can use AI to give everyone a voice (Xia et al, 2022, Chen et al, 2023, Berendt et al, 2020).

6. Benefits and Challenges of AI-Based Solutions

AI and knowledge technologies since the mid-seventies, increasingly integrated with human individual and collective knowledge processes. AI role in enhancing expressive language in intellectually disabled children, achieved by supporting their knowledge and linguistic expression abilities. In the ID group, difficulties with expressive language development during the school age require specific tools and educational paths. These difficulties are not solved just by the removal of the intellectual and behavioral limitations, and specific tools and educational paths are necessary to support them. (Chen et al, 2023, Kearney et al, 2022, Chen et al, 2020)

RRecent technological advances have helped AI support children with intellectual disabilities, but it's still in early stages. Research focuses on expressive language development, especially speaking and writing progress. Challenges include assessing expressive language level and personalizing education for each child. Both AI system and educators using AI must do these assessments. It's important to consider linguistic, grammar, conversational, and social skills. The educational approach should also address potential negative effects of typical AI tutoring.

6.1. Improving Engagement and Motivation

By delivering simplified and personalized explanations, AI can help fill the instructional gap and increase the chances for an intellectually disabled child to understand the task that they need to do. Additionally, voice-based AI can offer dialogue-based scaffolding during the task, providing the student with step-by-step guidance personalized to their current needs. This support can help reduce the high levels of task anxiety experienced by some intellectually disabled students and increase their task initiation and persistence (Kearney

et al, 2022). When they produce abrupt or conflicting responses, AI can remain objective and emotionally neutral, avoiding the frustration that might be induced if working with a human. In cases of challenging behavior, this support model is especially valuable as it allows work to be completed when a human may not be able to engage (Chen et al, 2023, Zhang et al, 2023).

Utilizing AI to support the learning of children with an ID is an innovative application of AI in education. It has the potential to substantially enhance the expressive language (EL) of all children and even more so for children with an ID. According to their current educational status, they receive more in-classroom assistance on EL class activities. Moreover, children with an ID often have foundational EL problems and take longer to express themselves properly. Their expressive language development is hindered by the fact that they receive more passive language education, have fewer meaningful language interactions and discussions, and have more difficulty understanding and memorizing complex linguistic explanations (Alam, 2023).

6.2. Ethical and Privacy Considerations

The technology and its developers/users must also be aware of the broader implications of creating a system that records and analyses user conversations. Secretly recording private conversations violates the principle of privacy and could lead to severe repercussions if discovered. It is important for developers to take steps to ensure that such misuse is prevented with visible or audible indicators showing when the system is active and recording. If such measures are not taken, unauthorized activation could occur, leading to accidental violations of privacy. To avoid accusations of intentional misuse, AI developers creating affective computing systems such as those described in this paper are encouraged to adopt and abide by ethical guidelines that are used in professional fields that make use of private user information. Such guidelines should be created with reference to existing privacy legislation, such as the GDPR, Data Protection Act, and the Family Educational Rights and Privacy Act (FERPA). Given that privacy and data protection laws vary by country, developers should take legal advice in order to comply with internationally recognized practices (Chen et al, 2020).

Given the development of such systems to aid a vulnerable group, ensuring that the technology respects the privacy and autonomy of the users is paramount. Firstly, user data privacy must be given the highest consideration. Voice samples, transcripts, and any identifiable information should be kept secure and not shared with other systems without user

consent. Data that has been de-identified, including transcripts and summaries, can however be used for further research and system improvement. Secondly, it is important that the users are able to give informed consent with regards to how their data is shared and used. Children may not understand the implications, so assistance from a legal guardian may be required. Additionally, ensuring that the technology functions to serve the users and not coerce them in any way is critical, This involves verifying that the system objectives align with the user's best interest and that the system does not make errors which could cause upset to the user (Chen et al, 2020).

7. Case Studies and Success Stories

The WebET system, consisting of the Easy-to-Read Web Browser and Easy-to-Read Web Page Composer, facilitates the use of the web for individuals with intellectual disabilities through personalized web page rendering and editing to create more accessible web content. IntraPeers is a social network for people with intellectual disabilities. Easy-to-read language technology is employed to support user-generated content and the use of the network's functionalities. Several other projects and products focused on improving web accessibility, incorporating speech technologies for individuals with ID, and addressing the broader population of individuals with disabilities have been successfully developed and deployed. They sound very promising and inspiring - is not that what we need more of in the field of AI and ID, both - great, impactful efforts but also sharing and learning from the success stories to stimulate further advancements and wider applications (Lin et al, 2023, Foong et al, 2024).

Some of the well-recognized success stories of AI-related efforts targeted towards children with ID are highlighted in this sub-section. An intelligent life planning system - What Do You Like? (WDYL)? supports adolescents with ID in person-centered planning and goal setting to help prepare for their transition from school to adult life. Tico is a tutoring system that uses a teachable agent to support students with mild ID in learning how to produce well-structured texts while addressing identified difficulties. A prototype chatterbot for children with autism and/or intellectual disability has been developed and tested. The chatterbot is part of an integrated system that also includes a virtual agent that recognizes user emotion, a human tutor, and offline components (Chen et al, 2023, Zhang et al, 2023).

7.1. Specific AI Tools and Platforms

The AI technologies developed in this field, particularly for children with intellectual disability, are still in a relatively early stage. There is a small number of systems available, each of which focuses on a different type of task and uses different technologies and AI methods. Additionally, the effectiveness of these technologies has not been extensively evaluated, especially with the actual target users. The speech and language deficits that characteristically accompany ID thus form a double challenge, both for evaluation/diagnosis and for the coaching system itself. Of the relatively few existing AI coaching systems for ID, most attempt to address language learning. Because of the speech and language challenges in this population, several of the existing systems use alternative communication methods, often involving visual supports or sign language.

Vygotsky emphasized the importance of social interactions and instruction as a facilitator of intellectual ability and the mastery of a new skill. New AI educational tools and platforms have the potential for significant development and support both at home and in the classroom. Sana, Gutierrez, and Goldstein have argued that "engineering intelligent, computer-based tutors holds the promise of providing one-on-one natural language tutoring to the masses, at the fraction of the cost of comparable human tutoring, and can ameliorate the current shortage of qualified human tutors." This paper aimed to provide a review of existing AI tools and platforms used for tutoring and coaching children with ID (Kamalov et al, 2023, Lin et al, , 2023).

8. Future Directions and Research Opportunities

Our goal is to promote collaboration between AI researchers and education experts to enhance the expressive language of intellectually disabled children through the development of AI-powered educational systems. By outlining research directions and collaboration opportunities, we seek to improve educational outcomes for these children using state-of-the-art AI technologies. Our structured summary aims to guide meaningful collaborations in this area, ultimately establishing AI as a core technology for improving educational support programs for children with intellectual disabilities.

8.1. Innovative AI Applications

The AI-based innovative methods as described in this section provide additional benefits. By replacing the human tutor, who is generally overloaded and scarce, with an AI virtual tutor, each child can get repetitive

practice as much as they need and in their own time and space. The AI system can also continuously assess the child's performance and customize the lesson plan for each child. Furthermore, the AI system is not biased and can be easily scaled. As intellectually disabled children can ultimately become independent learners, it is particularly important that concepts are explained in multiple ways and examples are provided in multiple contexts. Given this requirement for personalized instruction, it is a major challenge to design tutoring systems that can provide instruction uniquely tailored to the needs of each. The ability to remedy this situation constitutes one of the major strengths of intelligent tutoring systems. As a result, the potential of AI to contribute to the education and training of disabled children is strong and has been realized in many areas.

Key to preparing intellectually disabled children for an inclusive world is to innovate in the way we impart education to suit their learning difficulties and enhance their strengths so they can become the best they can be in their own unique way. The rapid growth in technological advancements provides several new age tools such as artificial intelligence, virtual reality, and robots, which can be combined with the old, proven techniques of speech therapy and drama to build innovative learning methods for the intellectually disabled.

8.2. Collaborative Interdisciplinary Research

The research introduces serious and high-risk challenges in AI, engineering, ethics, and child development. Interdisciplinary collaboration aims to address time, money, and skill-related tensions. The study focuses on modeling the expressions in non-verbal and early verbal children's speech and language across four research themes. The goal is to enable partner-free conversation, allowing children to express themselves and shape their personhood. The aim is to use AI to improve the expressive language of severely and profoundly intellectually disabled children, who do not engage in reciprocal conversation. The Expressive Language Machine (ELM) being developed computationally models, recognizes, and synthesizes the children's expressive language.

9. Conclusion and Implications for Practice

The study found that children with ID often struggle with emotional expression, which can be improved with the use of robots equipped with AI. Technology also has potential in enhancing the expressive language of children with ID. Key areas where technology can assist children with ID

include developing keypads with tactile feedback, using multimedia systems to prompt expression, teaching emotion and context with AI, and modeling human speaking to create robots that help children learn how to express themselves. Challenges to making this a reality involve improving the transparency and robustness of AI, understanding and trust by users, and more testing in real use. A cloud-based platform for expressive language training in children with intellectual disability was developed and tested with positive feedback. Educators and practitioners should prioritize the speech and language goals of the child when selecting AI tools and continue utilizing traditional methods alongside AI.

AUTHOR CONTRIBUTIONS

All the authors contributed to all parts of this study equally.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest in association with the present study.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors without undue reservation.

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