Enhancing AAC Systems Through Artificial Intelligence: Parent and Family Perspective on Limitations and Solutions

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BRIEF. This paper explores the potential of Artificial Intelligence in improving AAC systems, based on insights from parents and family members of individuals with complex communication needs.

ABSTRACT. Parents and family members of individuals with complex communication needs (CCN) participated in an 11-week study to evaluate current Augmentative and Alternative Communication (AAC) systems and explore how Artificial Intelligence (AI) could enhance these systems for improved communication competence. The study identified seven critical limitations of AAC systems: (1) operational challenges, (2) linguistic competence issues, (3) limited symbol sets, (4) insufficient practice opportunities, (5) difficulty expressing emotions, (6) the need for social competence, and (7) strategic competence. AI solutions, incorporating Natural Language Processing (NLP) and image processing, are shown to address these limitations, offering enhanced interfaces, predictive text, and personalized learning experiences. This paper highlights the potential of AI-powered solutions in transforming AAC devices, fostering better communication outcomes for individuals with CCN.

INTRODUCTION.

Augmentative and Alternative Communication (AAC) includes any type of communication other than spoken words. No-tech and low-tech AAC includes written words, sign language and communication boards. High-tech AAC includes anything that is technology based, such as a computer or tablet with an app or Speech Generating Devices that can provide a speech output [1]. More than 170 million people in the world have some kind of speech impairment [2]. Complex Communication Needs (CCN) arise from various conditions including Autism Spectrum Disorder (ASD), Cerebral Palsy (CP), Primary Progressive Aphasia (PPA), Dysarthria, Aphasia, and Speech Sound Disorders (SSD). CDC data shows ASD affects 1 in 36 children, with up to 50% needing AAC support. CP occurs in 1 in 345 children, with 31-88% experiencing dysarthria. Annually, 180,000 new aphasia cases are diagnosed in the U.S., while SSD affects 8-9% of young children. These conditions, along with PPA and dysarthria in adults, highlight the widespread need for AAC solutions [3]. These statistics highlight the substantial need for AAC solutions across different age groups and conditions, particularly as communication challenges can significantly impact daily interactions and quality of life. Despite their potential, AAC devices face significant challenges in usability, linguistic competence, and social interaction, including limited symbol sets and context-driven communication barriers. While advancements have been made, a significant gap remains in leveraging technologies like Artificial Intelligence (AI) to enhance AAC systems and address these limitations [4]. This study explores the role of AI-powered systems in overcoming these barriers, improving communication competence, and empowering AAC users by personalizing devices to meet individual needs.

MATERIALS AND METHODS.

To explore the perspectives of parents and family members on the use of AAC technology, we employed a mixed-methods approach comprising both quantitative and qualitative data collection techniques. The study was conducted over an 11-week period, beginning with the distribution of an online demographic survey to gather basic participant information. This survey included questions about participants' basic informsation, education levels, preferred communication platforms, and their children's age, grade, AAC device usage, and disability (See Table 1). Following the survey, 14 parents and family members of children who rely on AAC were selected to participate in one-on-one interviews. These interviews were conducted over participants' preferred communication platforms (Zoom, WhatsApp, Skype, etc.), ensuring ease of access and engagement.

The interview process involved a semi-structured format with 11 core questions (See Table S1), designed to elicit detailed responses about the challenges and benefits of AAC usage, including operational competence, linguistic abilities, and emotional expression. In addition, the final four weeks of the study explored how AI could potentially address the limitations identified by participants, with a focus on how personalized AI interfaces could enhance AAC devices. All interviews were recorded with participant consent and transcribed for analysis. The data was then analyzed through a 3-step process: (1) Categorizing responses with numerical values, (2) Analyzing the responses qualitatively using thematic analysis to identify

Subject #	Degree	Country	State	Age	Grade	AAC	Disability
					Table 1. Survey Demographic Data		
1	PhD	U.S.A.	AZ	14	9th	TouchChat	PPA
2	BS	India	GJ	17	12th	SpeakforYourself	Dysarthia
3	PhD	U.S.A.	CA	15	10th	Proloquo2Go	CP
4	MS	U.S.A.	CA	16	11th	Coughdrop	SPL
5	BS	U.S.A.	DE	16	10th	LAMP	PPA
6	MS	U.S.A.	CT	18	12th	Goally	Autism
7	PhD	U.S.A.	CA	17	11th	NikiTalk2P.	SPL
8	MS	U.S.A.	WI	15	10th	TDSnap	SPL
9	BS	U.S.A.	PA	14	9th	Proloquo2Go	CP
10	MS	U.S.A.	CA	17	11th	SonoFlex	CP
11	BS	U.S.A.	CA	16	11th	The Grid 2	PPA
12	MS	India	MH	14	9th	Avaz	SPL
13	BS	Canada	NS	18	12th	Talk Suite P.	Autism
14	PhD	U.S.A.	TN	15	10th	GoTalkNOW	Dysarthia

recurring themes, and (3) Grouping these themes into the seven primary AAC limitations identified by participants

RESULTS.

The study identified seven major limitations that participants reported regarding the use of AAC systems for their children (See Table 2). First, operational limitations were a common issue, with many parents noting that their children faced difficulties navigating the complex interfaces of AAC devices. Participants reported that the devices' numerous symbols and menus made it challenging for children to quickly locate the correct message or symbol, leading to frustration and communication delays. This operational struggle hindered the effectiveness of AAC devices in facilitating smooth communication.

Linguistic competence emerged as another significant barrier. Several parents noted that their children had difficulty constructing grammatically correct sentences using the AAC systems, particularly when attempting to express more complex thoughts. The lack of context-sensitive vocabulary and sentence structure suggestions compounded this issue, making it difficult for AAC users to express themselves clearly in conversation.

Limited symbol sets were also highlighted as a significant limitation. Parents reported that the AAC systems often lacked sufficient symbols to represent abstract or nuanced concepts, such as emotions, complex ideas, or specific actions. As a result, users had to combine multiple symbols or develop creative strategies to convey their intended messages, which often resulted in communication breakdowns or misunderstandings. Additionally, limited practice opportunities were noted by many participants. Since most children did not have regular opportunities to use AAC devices in natural settings, they struggled to develop fluency in communication.

Another barrier was difficulty expressing emotions. While AAC devices allowed users to express basic emotions such as happiness or sadness, more nuanced feelings like frustration or sarcasm were harder to convey. Parents mentioned that this limitation often led to miscommunication and emotional frustration, both for the child using the AAC device and for their communication partners.

Social competence was another key limitation identified in the study. Many parents observed that their children had trouble maintaining fluid social interactions due to the slow pace of communication facilitated by AAC devices. The time required to navigate the systems and construct sentences hindered their children's ability to participate in real-time conversations, which is crucial for effective social interaction.

Finally, strategic competence was a recurring theme. Parents noted that many children struggled with understanding and overcoming the inherent limitations of their AAC systems. This included figuring out how to communicate effectively in different social contexts, such as making requests or providing clarifications, especially when the symbols or vocabulary available on the devices were insufficient.

Table 2. AI Solutions for Enhancing AAC Competence				
Competence	Sub-Themes	Explanation	AI Solution	AI Understanding
Operational	Overwhelming list of words and pictures to choose from	Users struggle to navigate many symbols.	Personalized Interface and Navigation	An AI-powered interface adjusts the layout to prioritize commonly used symbols for quicker access.
	Locating specific vocabulary within the AAC system	Finding specific words can be difficult.	AI-powered recommendations	AI analyzes selection patterns and predicts the user's most likely vocabulary choices, optimizing symbol organization.
Linguistic	Limited Symbol Sets	Fewer symbols limit expression.	Personalized Vocabulary Learning & Prediction	AI recommends new vocabulary based on user history, improving language acquisition.
	Limited Practice Opportunities	Fewer chances for users to practice.	Interactive vocabulary games	AI-driven games help users practice vocabulary in an engaging and dynamic way.
	Speed to construct relevant phrases	Slow phrase construction can hinder communication.	Integration with environmental context	AI suggests relevant symbols or phrases based on the user's surroundings, speeding up phrase construction.
Social	Limited communication speed	Slower speech impacts conversation flow.	Predictive sentence building for social contexts	AI suggests context-appropriate greetings and conversation starters, aiding social interactions.
	Difficulty expressing emotions	Emotions are hard to convey with symbols.	Emotional Expression and Understanding	AI identifies the user's emotional tone and offers symbols that reflect their feelings, enhancing clarity and connection.
Strategic	Dealing with breakdowns in conversation	Users may lack symbols for needed words.	AI-powered prediction of communication needs	AI anticipates needs based on context and suggests words or phrases, preventing breakdowns.
	Cognitive demands	Strategic planning can be hard for some users.	Personalized communication strategy tutorials	Interactive AI tutorials teach communication strategies to help users handle various social situations.
	Confidence and social anxiety	Communication difficulties cause anxiety in social settings.	AI-powered environmental scanning & suggestion	AI analyzes the environment and suggests symbols to help users respond confidently in real-life scenarios, reducing anxiety.

Overall, these findings underscore the importance of addressing these limitations to enhance the effectiveness of AAC systems. The study also highlighted the potential role of AI in improving AAC systems by making them more adaptive, personalized, and contextually aware, thereby mitigating the challenges identified by participants. Analysis of participant's responses showed that 73% believe AI integration could enhance AAC devices by improving adaptability, personalization, and contextual awareness (See Chart S1).

DISCUSSION.

The findings of this study underscore several critical limitations that currently hinder the effectiveness of AAC systems for individuals with complex communication needs (CCN). Other research has documented several key barriers that special educators face when implementing AAC devices. These include technical challenges in device operation, extensive training needs coupled with limited training opportunities, and insufficient technical support. Special educators also struggle with inadequate assessment tools and face difficulties in consistently monitoring student progress. These limitations significantly impact their ability to effectively support students who rely on AAC for communication [5]. This study contributes to a deeper understanding of how these barriers affect users from the perspective of parents and family members, who are integral to the AAC learning process.

The potential for AI to address these limitations is promising. AI-powered systems could provide personalized interfaces, tailoring the selection of symbols and vocabulary to the individual user's communication patterns and needs. For example, AI could predict frequently used symbols, dynamically adjust scanning speeds, and recommend contextually relevant phrases, reducing the cognitive load for users. These features could significantly improve operational competence, allowing users to communicate more efficiently [1,4].

In terms of linguistic competence, AI could play a crucial role in promoting grammatical accuracy and sentence structure by analyzing users' communication patterns and suggesting improvements. Furthermore, predictive text and symbol recommendations could allow users to express more complex thoughts, overcoming the limitations of current AAC devices.

Limited practice opportunities are another barrier that can be alleviated by AI-based learning tools. By providing interactive, context-driven scenarios where users can practice their communication skills, AI could enhance AAC systems' ability to support language acquisition. Additionally, incorporating emotion-recognition algorithms could help address the challenge of emotional expression, offering AAC users ways to convey more nuanced feelings, which are often overlooked by traditional systems.

The role of social competence is also crucial in communication, and AI could support this by providing context-aware communication suggestions. For instance, in social situations where turn-taking or appropriate topic maintenance is critical, AI could guide users through these processes, ensuring smoother conversations.

Overall, the integration of AI into AAC devices offers a transformative opportunity to overcome the current limitations faced by users with CCN. However, further research is needed to explore the long-term impacts of AI-enhanced AAC devices and to assess their real-world effectiveness in diverse environments.

CONCLUSION.

The study demonstrates significant potential for AI to transform AAC systems. By addressing current limitations, these technologies can help individuals to develop their operational, linguistic, social and strategic competence and empower them with complex communication needs to communicate more efficiently, confidently, and expressively. The research emphasizes the importance of personalized, adaptive solutions that consider individual user needs and communication contexts, ultimately promoting greater independence and social inclusion.

SUPPORTING INFORMATION.

In the supplementary information document, there is a pie chart showing the results of participants' responses to AI solutions and two tables. Table S1 includes interview questions and Table S2 includes AI Solutions for Enhancing AAC.

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