Invited Commentary

Psicologia: Teoria e Prática, *26*(1), ePTPIC16624. São Paulo, SP, 2024.
ISSN 1516-3687 (print), ISSN 1980-6906 (electronic version). **Evaluation system:** double-blind review.
https://doi.org/10.5935/1980-6906/ePTPIC16624.en
Universidade Presbiteriana Mackenzie

Current Trends in Augmentative and Alternative Communication Intervention for Minimally Verbal Autistic Children

Oliver Wendt[1,2]

[1] University of Potsdam (Universität Potsdam)
[2] Purdue University

Author Note

Oliver Wendt https://orcid.org/0000-0002-7363-3779

Correspondence concerning this article should be addressed to Oliver Wendt, Cognitive and Emotional Disabilities, College of Human Sciences, University of Potsdam, 14476, Potsdam, Germany. Email: oliver.wendt@uni-potsdam.de

Individuals with autism spectrum disorder (ASD)[1] experience a severe delay or atypical trajectory around language and communication development (American Psychiatric Association, 2013). While about 50 % of children on the autism spectrum eventually demonstrate the ability to produce spoken phrases by the time they enter primary school, an estimated 30-40 % are affected by persistent and severe language impairments (Koegel et al., 2020; Tager-Flusberg & Kasari, 2013). This subpopulation has often been described as "minimally verbal" or "non-verbal." In clinical and educational practice, the most immediate need for learners with severe, minimally verbal autism is establishing functional communication to meet basic wants and needs and participating in daily life. Augmentative and Alternative Communication (AAC) interventions have been developed and implemented to address this most pressing need. AAC strategies range from low-technology paper-based communication boards (Ratusnik & Ratusnik, 1974) over mid-technology devices that allow digitized speech output to the more current and widely used high-technology options with synthetic speech, including speech-generating devices (SGDs) and mobile technologies such as tablet devices with corresponding mobile applications (Waddington et al., 2014; Wendt et al., 2019b). The essential objective of AAC interventions is to facilitate communication and language development through any combination of modalities (e.g., remaining natural speech, synthetic/digitized speech output, graphic symbols, manual signs, gestures, body language, etc.). Common consensus exists in clinical practice that AAC interventions benefit a considerably large population, including not only those who are currently affected by delays or impairments in speech and language but also infants and toddlers who are at risk for later neurodevelopmental conditions. There is agreement that AAC interventions for minimally verbal children should begin as soon as the first warning signs appear. Early AAC intervention may lead to reduced severity levels of language and intellectual impairment and can be a precursor to optimized long-term intervention outcomes (Vismara & Rogers, 2017).

Current State of AAC Research

To attain these more significant intervention outcomes, contemporary AAC research has started to explore two major areas with the potential to maximize the benefits of AAC intervention efforts: (a) research and development of new AAC interfaces using mobile technologies and (b) instructional approaches to guide the implementation of AAC technologies.

New AAC interfaces: Mobile technology includes portable electronic devices that use a liquid crystal display (LCD) to generate digital images, which can be controlled by gestures on the screen via the user's fingers, through a stylus, or by providing input using a digital keypad (Fietzer & Chin, 2017). When mobile devices are combined with AAC applications (aka "apps"), they can function as speech-generating devices (SGDs). This technology provides access to digitized or synthesized speech output (Schlosser & Koul, 2015). In contrast to dedicated SGDs, a mobile platform typically serves various functions beyond communication processes (e.g.,

1 Some individuals prefer identity-first language (e.g., autistic people) while others prefer person-first language (e.g., people with autism). This article uses both language forms interchangeably.

provision of multi-media content, social media communities, photo/video producing features, etc.). The rapidly rising popularity of mobile technologies left a mark on the field of AAC, igniting a development that McNaugthon and Light (2013) called the "mobile technology revolution": Tablet devices such as the Apple iPad® brought the field of AAC much closer to the mainstream. Individuals needing AAC are no longer dependent on specific dedicated SGDs; they can simply access conventional technologies "off the shelve" to help with their communication needs.

For the population of minimally verbal autistic individuals, clinical AAC research has started to develop autism-specific mobile solutions that directly target critical speech and language milestones while considering the cognitive and sensory processing characteristics of autistic learners (Wendt et al., 2020). Using participatory and co-design approaches, applied AAC research can elicit experiences from autistic end users and their caretakers, clinicians, and teachers. This process can be used to pinpoint subtle but essential features that need to be considered in the design of software applications (Brosnan et al., 2016; Wendt et al., 2019b). As soon as newly developed mobile technologies are ready for clinical testing, generating research evidence to document the effects and provide proof-of-concept is another essential step (Wendt et al., 2019b). Evidence generation for mobile AAC technologies can involve three major approaches: (a) Single-case experimental designs to show effects through repeated measurement of behavior and replication across and within participants; (b) quantitative electroencephalograms to investigate and demonstrate improvement in speech and language-related symptoms pre- and post-intervention; and (c) Google Analytics data to track and document mobile application usage (Wendt et al., 2016). As an example, Wendt and colleagues (2019a) implemented a multi-baseline, single-case experiment to explore the efficacy of an iPad-based speech-generating device. Two adolescents and one young adult with a diagnosis of severe autism spectrum disorder showed substantial gains in the acquisition of initial requesting skills and their generalization. Yet, mixed results were observed when the intervention goal included natural speech production. Keeping these research and development principles in mind, novel mobile AAC technologies can help autistic learners explore their communication abilities thoroughly, amplify AAC intervention outcomes, and enable these individuals to participate better in educational and social settings.

Instructional approaches: Any AAC technology does not teach itself but demands a proper intervention protocol or set of instructional procedures to be effectively introduced to the prospective AAC user. The individual needs concrete guidance to attain developmentally appropriate AAC goals and develop linguistic, operational, social, and strategic competence (Beukelman & Light, 2020). In previous years, AAC interventions for minimally verbal autistic individuals have primarily concentrated on establishing functional communication and teaching essential communicative functions such as requesting, labeling, and rejecting. Utterances generated through AAC modalities typically consisted of single-word productions. Nowadays, the challenge for the AAC field is creating autism-specific interventions that systematically help learners move from single to multiple-word utterances. Targeting a communicative repertoire that enables the individual to generate more complex sentences and multi-word utterances would be more advantageous. This demands a unique set of instructions that accompany an AAC strategy (whether the individual is using, e.g., manual signs or low- or high-technology speech-generating devices). More advanced instructional procedures enable learners to understand and build language through these alternative modalities.

Contemporary AAC intervention research has focused on two approaches that have been widely used for targeting a variety of language-related outcomes via AAC: language modeling and matrix training. Initial investigations have demonstrated promising results for each set of intervention procedures. Language modeling or augmented input approaches are based on aided language modeling or aided language stimulation (Drager et al., 2006; Goossens', 1989). These build upon the established practice that the learner can acquire AAC targets through observing and mimicking an interventionist who demonstrates how to produce correct symbol utterances and combinations using an AAC strategy. A recent systematic review by Allen et al. (2017) synthesized *N* = 19 AAC intervention studies using an augmented input approach with learners with developmental disabilities (including those with autism spectrum disorder). Allen and colleagues found that these techniques enhance single-word vocabulary skills and promote the development of multi-word symbol phrases. The authors make the case that augmented input approaches meet the criteria for "promising evidence-based practice" as minimal quality appraisal criteria have been fulfilled (Reichow, 2010). Future research must clarify which AAC systems correspond with augmented input techniques and the best dosage for implementing expanded input approaches in autistic learners. Along the same lines, it would be productive to know the more concrete profiles of those learners who benefit from an augmented input intervention (Allen et al., 2017).

Matrix training represents another innovative approach for teaching AAC learners the generation of multi-symbol utterances to compose complete sentences; additionally, it promotes the generalization of newly learned language skills (Chae & Wendt, 2012). Matrix strategies use linguistic elements (e.g., nouns, verbs, etc.) presented in systematic combination matrices arranged to induce generalized rule-like behavior. The clinician models combining a limited set of words in one semantic category with another set in a related semantic category to facilitate the child's acquisition of generalized combining of lexical items (Nelson, 1993). Matrix training targets a process known as "recombinative generalization." This effect emerges when the learner can discriminate relations between symbols and their referents and recognizes a general rule to compose novel symbol combinations from two or more semantic classes. Recombinative generalization helps language learners comprehend and express untrained utterances. Matrix training can be implemented via proper mobile AAC applications on mobile devices (as shown in Wendt et al., 2019b; Wendt, 2023). A systematic review and meta-analysis by Simeone et al. (2023) evaluated the results from *N* = 26 matrix training intervention studies, including individuals with autism spectrum disorder. Interventions included AAC and traditional modalities (e.g., speech and language therapy without augmenting strategies). The authors concluded that matrix training approaches are an effective instructional method for autistic learners when targeting acquisition, recombinative generalization, and maintenance of various language learning outcomes. The What Works Clearinghouse (WWC) Single-Case Design Standards (Kratochwill et al., 2010) determined that matrix training strategies meet the criteria for evidence-based practice. Future research must illuminate the active mechanisms responsible for learning effects while looking at ways to refine and manualize existing matrix training approaches for optimized implementation in clinical practice (Simeone et al., 2023).

The continued emergence of empirically driven and experimentally based clinical AAC research that encompasses the development of innovative technology solutions and research on the most productive instructional approaches bodes very well for moving the field of AAC interventions for autistic learners toward evidence-informed practice. It is refreshing to look at the potential of the described AAC research directions. The AAC field was primarily concerned with the most suitable device or modality for a long time. However, AAC-based interventions do not "teach themselves"; merely exposing the individual to specific materials or devices does not automatically result in skill acquisition. As Mirenda (2009) points out, the success or failure of an (AAC or other) intervention "is not simply a matter of choosing symbols or devices; instructional variables are also critically important. Indeed, when AAC fails to result in functional communication, this failure usually reflects limitations in the procedures and methods used for instruction rather than an inherent problem with AAC itself" (p. 16). Novel research directions will enhance our understanding of proper AAC interfaces and accompanying instruction that truly helps minimally verbal individuals with autism to maximize their communication skills, thus addressing a very current and essential challenge in the autism field.

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