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Effects of Aided Augmented Input on Autism Spectrum Disorder: A Scoping Review

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Resumo: Pessoas diagnosticadas com transtorno do espectro do autismo (TEA) frequentemente apresentam necessidades complexas de comunicação e desafios no desenvolvimento. Como resposta, diversas estratégias de intervenção que incorporam recursos e suportes de Comunicação Aumentativa e Alternativa (CAA) são utilizadas. Uma abordagem de destaque é a entrada aumentada assistida, uma intervenção que utiliza símbolos visuais fornecidos por um parceiro de comunicação para apoiar tanto a comunicação expressiva quanto a compreensão. Esta scoping review tem como objetivo analisar a literatura existente sobre essa intervenção em crianças e adolescentes com TEA, seguindo as diretrizes do PRISMA-ScR. Foram analisados 17 estudos extraídos de bases de dados como Web of Science, Scopus e PubMed, com foco nos recursos de CAA utilizados, nos contextos de implementação e nos principais achados. Os resultados sugerem que a entrada aumentada assistida beneficia usuários com TEA ao melhorar a comunicação, as habilidades sociais e o comportamento. No entanto, são necessárias mais pesquisas para compreender melhor seus efeitos.

Palavras-chave: *Entrada Aumentada Assistida; Comunicação Aumentativa e Alternativa; Transtorno do Espectro do Autismo; Revisão sistemática da literatura.*

Abstract: People diagnosed with autism spectrum disorder (ASD) often experience complex communication needs and developmental challenges. As a result, various intervention strategies incorporating augmentative and alternative communication (AAC) resources and supports are utilised. One notable approach is aided augmented input, an intervention that involves using visual symbols provided by a communication partner to support both expressive communication and comprehension. This scoping review aims to examine the existing literature on this intervention in children and adolescents with ASD, following PRISMA-ScR guidelines. 17 studies from databases such as Web of Science, Scopus, and PubMed were analysed, focusing on AAC resources, implementation contexts, and key findings. Results suggest that aided augmented input benefits users with ASD by enhancing communication, social skills, and behaviour. However, further research is needed to better understand its effects.

Keywords: *Aided Augmented Input; Augmentative and Alternative Communication; Autism Spectrum Disorder; Systematic literature review.*

The need to improve the quality of life for people with complex communication needs has led to the use of augmentative and alternative communication (AAC) with or without assistance in numerous interventions (Cerpa Reyes, Jorquera Arellano & Toro Lisboa, 2023). Recent research has highlighted the effectiveness of AAC interventions for people with autism spectrum disorder (ASD) who have these needs, especially children, showing an increase in communicative opportunities (Landa, 2018; Lorah et al., 2024; Pereira et al., 2020; Therrien, Light & Pope, 2016). The Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5; APA, 2013) serves as the leading reference for diagnosing mental health conditions. According to this manual, people with ASD experience significant difficulties in social communication and interaction, along with restricted and repetitive patterns of behaviour, interests, or activities.

Estimates indicate that ASD affects over 70 million people worldwide. Current research suggests a global prevalence of autism ranging from 65 to 72 cases per 10,000 individuals. Approximately 30% of people with ASD have complex communication needs that significantly limit their ability to express themselves through speech, sign language, or writing (Holyfield et al., 2017; WHO, 2023). These challenges often include difficulties in vocabulary development and responding appropriately in social interactions with one or multiple conversational partners. Such communication barriers not only hinder social

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engagement in daily life but may also influence behaviour and have long-term developmental consequences.

Due to its characteristics, aided augmented input emerges as an approach that can be beneficial for users with ASD who have complex communication needs (Biggs, Carter & Gilson, 2018; Drager, 2009). Also known as "natural aided language stimulation," this AAC approach is designed to support communication by fostering both expressive and receptive language skills. This strategy involves using visual symbols provided by a communication partner to support expressive communication and comprehension. Rather than relying solely on verbal expression, it encourages the integration of graphic symbols as a viable mode of communication (Goossens & Crain, 1986; Wandin et al., 2023). The primary focus of this approach is to enrich linguistic input during various communicative situations, including daily interactions, routine activities, and the delivery of instructions in therapeutic settings. For this intervention to be effective, communication partners play a crucial role in creating a supportive social environment by providing consistent verbal input. This ensures that the language experiences of people using AAC resemble those of individuals with typical language development. In practice, communication partners actively model AAC use in natural and dynamic interactions, incorporating graphic symbols to enhance communication with additional detail and context (Chazin, Ledford & Pak, 2021; Muttiah et al., 2022).

However, previous reviews of this strategy remain limited in scope (Chazin, Ledford & Pak, 2021), outdated in relation to recent technological developments (Sennott, Light & McNaughton, 2016), or primarily focused on broader language modelling methodologies rather than specifically on aided augmented input (Wandin et al., 2023). For example, training with large amounts of linguistic input can help users learn grammatical and semantic patterns and rules, thus producing coherent and relevant texts or speeches (Gibson, Pritchard & de Lemos, 2021; Jensen de López, Kraljević & Struntze, 2022; Shi et al., 2021). This differs from aided augmented input, where additional support is provided to promote receptive and expressive communication during natural interactions.

Consequently, the purpose of this scoping review was to deepen knowledge about aided augmented input interventions and their effects on participants with ASD, by systematising the available information. This study aims not only to consolidate understanding in this area of study in a simplified manner but also to facilitate the design of future interventions.

METHOD

A scoping review was conducted with the aim of identifying and analysing studies that examine the use of strategies based on aided augmented input, as well as the effectiveness of different types of AAC supports in users with ASD. Additionally, the factors influencing their implementation and the outcomes achieved were evaluated. For this purpose, the guidelines outlined in the PRISMA framework for scoping reviews (PRISMA-ScR; Tricco et al., 2018) were followed, adapting them to the objectives of the current research. Throughout this study, the term “aided augmented input” is used consistently to refer to partner-provided aided language modelling, including related terms, such as aided language stimulation and aided AAC modelling. Terminology was standardised during manuscript revision to reduce conceptual ambiguity across studies.

Inclusion and exclusion criteria

The studies included in the review had to meet the following criteria: a) original experimental studies with specified outcomes; b) intervention methodology based on aided augmented input; c) participants aged 3 or older, diagnosed with ASD, and in school age or adolescence; d) published in English, due to the widespread use of this language in the global scientific community, its predominant indexing in databases and journals, and its relevance in scientific communication; and e) studies published between 2010 and 2024, inclusive. This time frame was selected to capture contemporary AAC practices, particularly considering the rapid evolution of digital AAC systems, speech-generating devices, and visual scene display technologies over the last decade (Durán Cuartero, 2021). Earlier seminal studies (e.g., Drager et al., 2006; Goossens & Crain, 1986) were used for conceptual background but were not included in the empirical synthesis unless they met inclusion criteria.

Additionally, the exclusion criteria were: a) studies that used methodologies not aligned with the characteristics of aided augmented input; b) other systematic reviews, such as works not published in scientific journals, intervention protocols, press releases, conference presentations, abstracts, and letters to the editor; c) studies that included only participants with conditions other than ASD; and d) works that did not describe the effects, outcomes, or conclusions of the intervention.

Identifying relevant studies

The literature search was conducted on the Web of Science, Scopus, Semantic Scholar, PubMed, and PsycInfo databases from March 19, 2024, to April 26, 2024. To enhance transparency and replicability, the search strategy was developed in collaboration with an experienced university librarian. The search process followed an iterative approach, including pilot searches to refine keywords and Boolean combinations. Controlled vocabulary (e.g., MeSH terms in PubMed and Thesaurus terms in PsycInfo) was combined with free-text terms to maximise sensitivity and specificity. The main terms of interest for this review were: "autism spectrum disorder", "ASD", "augmentative and alternative communication", "AAC", "aided augmented input", "aided language stimulation", "aided language modelling", "aided AAC input", "communication", and "language".

The final search string was adapted to each database syntax but maintained the same conceptual structure: ("aided augmented input" OR "aided language stimulation" OR "aided language modelling" OR "aided AAC modelling" OR "augmented input") AND ("augmentative and alternative communication" OR "AAC") AND ("autism spectrum disorder" OR "ASD") AND ("communication" OR "language"). Boolean operators were applied systematically, with "OR" used to combine synonymous intervention terms and population descriptors, and "AND" used to intersect intervention, population, and outcome domains. Truncation and quotation marks were applied when permitted to ensure the retrieval of both exact phrases and relevant variations.

Although aided augmented input is conceptually situated within the broader field of AAC, the deliberate combination of intervention-specific terms (e.g., "aided language modelling") with broader AAC-related descriptors using the Boolean operator "AND" was intended to ensure alignment with the AAC theoretical framework. This approach helped exclude studies that employed visual supports or multimodal input without explicitly incorporating AAC systems or principles. This trade-off reflects a balance between specificity and sensitivity in the search strategy and is consistent with the aim of identifying studies that explicitly position aided augmented input within AAC-based interventions.

A total of 1141 papers were identified, which were reduced to 1019 after removing duplicates. Upon reviewing titles and abstracts based on the established eligibility criteria, 965 papers were excluded. Then, 54 papers were analysed in detail, of which 37 did not meet specific criteria and were excluded. 17 papers were finally included in the scoping review, as they met all criteria (Figure 1).

Interrater reliability

Following the methodology outlined in the scoping review by Wandin et al. (2023), the interrater reliability was assessed using the Percentage Agreement index (Figure 2).

$$\boldsymbol{Percentage\ Agreement} = \frac{\boldsymbol{Number\ of\ Agreements}}{\boldsymbol{Total\ Number\ of\ Decisions}} \times \mathbf{100}$$

Figure 2. Percentage Agreement Index Equation

Interrater reliability between the primary author and the supervisor for the title and abstract screening was 96.3%. During the full-text review, the two evaluators each assessed 50% of the remaining 54 full texts (27 texts each). The initial inter-observer agreement for the full-text screening was 85% (83% and 87%) before consensus discussions. All discrepancies were resolved through discussion, ensuring unanimous agreement on the final selection.

RESULTS

This research study analysed a sample of 17 academic papers published between 2010 and 2024, from four different countries. These countries were: the United States (70.59 %), Canada (5.88 %), the United Kingdom (5.88 %) and South Africa (17.65 %). Specifically, the United States was represented by the papers published by Allen et al. (2021), Brady et al. (2015), Dorney and Erickson (2019), Finke et al. (2017), Harjusola-Webb and Robbins (2012), Kasari et al. (2014), Lorah, Karnes and Speight (2015), McFadden, Kamps and Heitzman-Powell (2014), Muttiah et al. (2022), Park, Moulton and Laugeson (2023), Remner et al. (2016), and Schlosser et al. (2013). Canadian literature consisted of the work published by Trottier, Kamp and Mirenda (2011). The United Kingdom was represented by Emerson and Dearden (2013); and South Africa contributed the papers by Hassim (2019), Laher and Dada (2023), and Ngwira (2019). Variability in the level of detail reported across studies reflects differences in study design, reporting quality, and relevance to the specific aims of this review. Studies with more rigorous designs (e.g., randomised controlled trials) or those directly addressing core mechanisms of aided augmented input are described in greater depth to support interpretability.

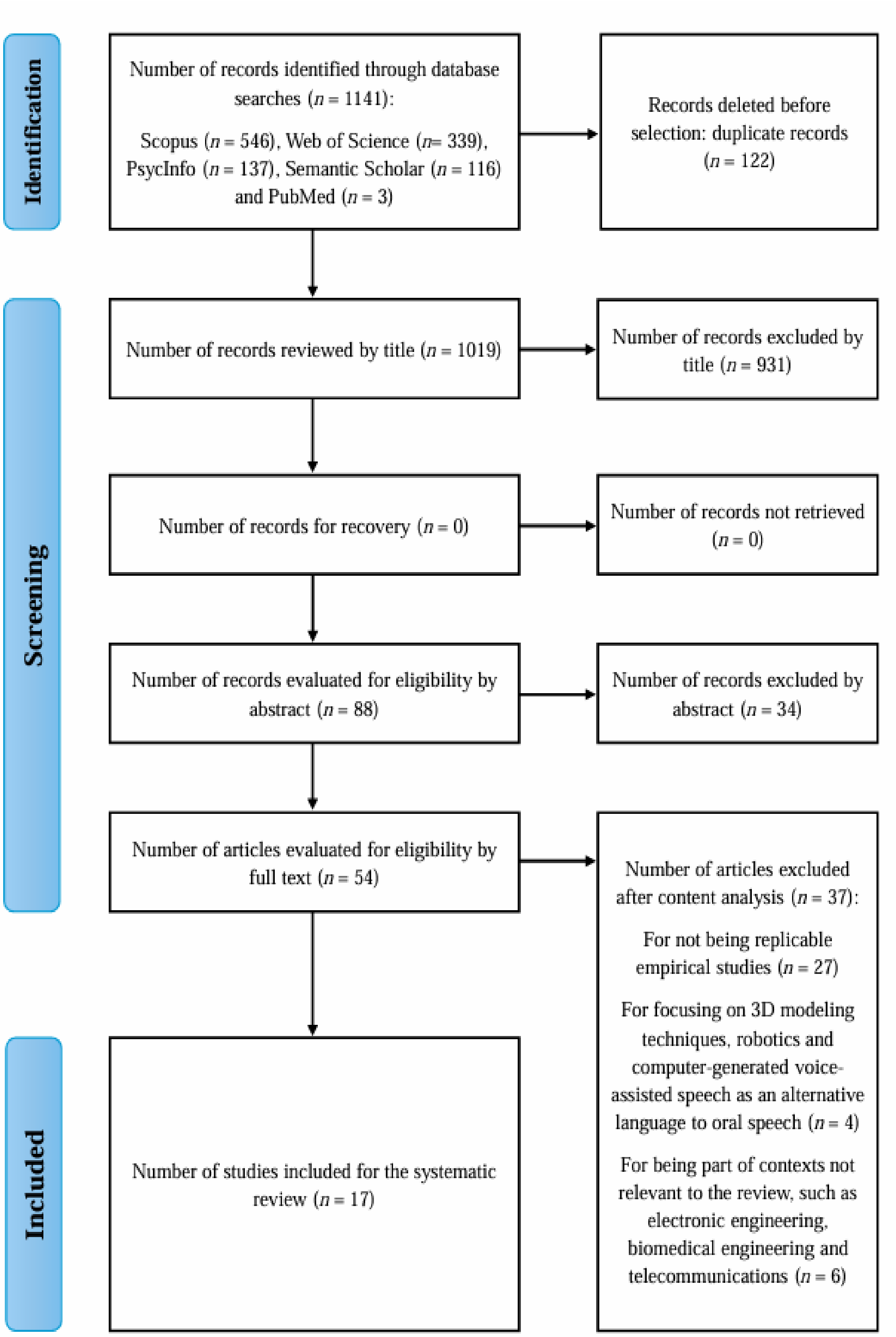

Figure 1. PRISMA flowchart of study selection process

The extracted characteristics from the studies included information about the authors, year of publication, study design, sample size, characteristics of the experimental group, intervention tools, and follow-up (Table 1). Among all the studies analysed, the total number of participants meeting the inclusion criteria proposed by the authors was *n* = 184, from whom *n* = 134 (72.83 %) were male participants and *n* = 33 (17.93 %) female participants. There were only two studies that did not specify the gender of participants in the analysed sample (Allen et al., 2021; Remner et al., 2016). However, none of the studies divided the groups by gender for analysis. Instead, analyses were conducted either globally or individually.

Table 1. Characteristics of the studies

	Design	Sample	Characteristics of the experimental group	Intervention tools	Follow-up
Allen et al. (2021)	Controlled within-subjects design	*n* = 11	Moderate to severe ASD, comorbidity with intellectual deficit	Images, real objects, and videos with iPad™	No tracking
Brady et al. (2015)	Controlled within-subjects design	*n* = 10	ASD with limited expressive vocabulary	Multimodal elements with iPad™ or computer	Between 2 and 40 sessions
Dorney & Erickson (2019)	Mixed methods experimental design	*n* = 13	ASD with limited expressive vocabulary	Communication matrix and AAC classroom elements (PCS and PECS)	No tracking
Emerson & Dearden (2013)	Controlled single-case design	*n* = 1	ASD with restricted receptive language and basic verb comprehension	Images and words paired	Several weeks (unspecified)
Finke et al. (2017)	Controlled within-subjects design	*n* = 6	ASD with experience using AAC	Multimodal communication strategies, including high-tech AAC, sign language, gestures, and speech	3 months
Harjusola-Webb & Robbins (2012)	Controlled within-subjects design	*n* = 3	ASD capable of communicating with gestures and vocalisations	Teacher training package on naturalistic intervention	No tracking
Hassim (2019)	Experimental crossover design between subjects	*n* = 21	ASD able to recognise objects and prepositions	ICT support for iPad™, real colour photographs, and assisted symbols	Several weeks (unspecified)
Kasari et al. (2014)	Randomised longitudinal regression models	*n* = 61	Minimally verbal ASD	Naturalistic speech and communication-generating device	3 months
Laher & Dada (2023)	Alternative treatment design (randomised)	*n* = 6	Children with complex communication needs, including ASD	Facilitating boards with 12 PCS symbols	3 weeks
Lorah, Karnes & Speight (2015)	Multiple baseline design	*n* = 2	ASD with an absent or weak verbal repertoire	ICT support with voice generator; experimenter vocally presented stimuli	21 sessions
McFadden, Kamps & Heitzman-Powell (2014)	Multiple baseline design	*n* = 4	ASD with severe social functioning deficits	Peer Networks and Fundamental Response Training	Several weeks (unspecified)
Muttiah et al. (2022)	Single-case multiple probe across participants	*n* = 3	ASD with a presymbolic level or lower on communication and developmental delay	Low-tech VSDs and aided modelling	No tracking
Ngwira (2019)	Quasi-experimental design	*n* = 17	ASD with deficits in receptive language skills	12 verbal instructions combined with pictograms presented on iPad™	No tracking

Table 1. Continued.

	Design	Sample	Characteristics of the experimental group	Intervention tools	Follow-up
Park, Moulton & Laugeson (2023)	Randomised controlled trial design	*n* = 5	ASD with moderate involvement and intellectual disability	Parent-Assisted Social Skills Training Program	Weekly tasks
Remner et al. (2016)	Controlled within-subjects design	*n* = 10	Moderate to severe ASD with object recognition skills	Wooden blocks, jewellery boxes, communication board, and iPad™	No tracking
Schlosser et al. (2013)	Randomised controlled within-subjects	*n* = 9	ASD with interests in electronic tools	Directives, figures, other accessories, and iPad™	No tracking
Trottier, Kamp & Mirenda (2011)	Multiple baseline design	*n* = 2	ASD capable of making requests with at least 10 pictograms	Games tailored to individual interests and abilities	No tracking

Note: PCS: Pictographic Communication System; PECS: Image Exchange Communication System; AAC: Augmentative and Alternative Communication; ICT: Information and Communications Technologies; VSDs: Visual Scene Displays.

All participants had an ASD diagnosis and did not present any visual or hearing challenges. Most studies (76.47%) established the ASD diagnosis based on previous reports by developmental pediatricians, neurologists, or clinicians, independently from the researchers. There were three studies (17.65%), namely Finke et al. (2017); Harjusola-Webb and Robbins (2012) and Brady et al. (2015), that confirmed the ASD diagnosis using the Diagnostic and Statistical Manual of Mental Disorders–Fourth Edition, DSM-IV (APA, 1994). One study (5.88%), conducted by Kasari et al. (2014), validated the diagnosis using the Autism Diagnostic Observation Schedule–Second Edition (ADOS-2; Lord et al., 1999).
Across the 17 included studies, participant ages ranged broadly from early childhood to adolescence. Most investigations focused on preschool and early school-aged children (approximately 3 to 8 years old; e.g., Kasari et al., 2014; Brady et al., 2015; Schlosser et al., 2013), while several studies included older elementary-aged children and preadolescents up to 12–13 years of age (e.g., Finke et al., 2017; Muttiah et al., 2022). A smaller number of studies extended into adolescence, with participants reaching approximately 15–16 years (e.g., Emerson & Dearden, 2013). Overall, the majority of the evidence base reflects interventions implemented during early and middle childhood, with comparatively limited representation of older adolescents.

Although being conducted in a school setting was not an inclusion criterion, the majority of the studies were conducted in educational environments. Specifically, ten studies were conducted in school settings, including preschools and classrooms (Dorney & Erickson, 2019; Finke et al., 2017; Harjusola-Webb & Robbins, 2012; Laher & Dada, 2023; Lorah, Karnes & Speight, 2015; McFadden, Kamps & Heitzman-Powell, 2014; Trottier, Kamp & Mirenda, 2011). Four studies were conducted in clinical or structured settings, including university research laboratories or controlled clinical environments (Brady et al., 2015; Hassim, 2019; Ngwira, 2019; Remner et al., 2016). Three studies were carried out in naturalistic settings such as the participants' homes or family-inclusive group settings (Allen et al., 2021; Muttiah et al., 2022; Park, Moulton & Laugeson, 2023). Additionally, Emerson and Dearden (2013) implemented their intervention in an individualised educational setting tailored to the participant's needs, while Schlosser et al. (2013) conducted their study in a controlled experimental laboratory environment.

These findings are consistent with the trend observed in previous research, where school and clinical settings are commonly chosen for interventions targeting communication, social and behavioural skills in children with ASD (Du, Guo & Xu, 2024; Sutton, Webster & Westerveld, 2019). This distribution highlights the importance of selecting contexts that provide consistent routines and opportunities for social interaction, essential for generalising learned skills.

In the majority of the studies, the interventions were implemented by a variety of professionals, reflecting a multidisciplinary approach to aided augmented input strategies: Teachers/Educators participated in 29% of the studies (Dorney & Erickson, 2019; Harjusola-Webb & Robbins, 2012; Laher & Dada, 2023; McFadden, Kamps & Heitzman-Powell, 2014; Trottier, Kamp & Mirenda, 2011), primarily in school settings, where they were trained to use aided augmented input strategies. Speech therapists were involved in 29% of the studies (Allen et al., 2021; Brady et al., 2015; Finke et al., 2017; Kasari et al., 2014; Remner et al., 2016), focusing on AAC interventions and providing visual models with speech-generating devices. Researchers/Specialists in AAC conducted 24% of the studies (Schlosser et al., 2013; Hassim, 2019;

Ngwira, 2019; Muttiah et al., 2022), designing and supervising interventions in clinical and experimental settings. Parents were involved in 6% of the studies (Park, Moulton & Laugeson, 2023), supporting generalisation of social skills in family-inclusive group settings. Other educational professionals, including paraprofessionals and teaching assistants, supported the implementation of AAC strategies in 12% of the studies (Dorney & Erickson, 2019; Laher & Dada, 2023).

The implementation of aided augmented input varied in flexibility across the studies. In school-based interventions, teachers and educational staff tailored the use of AAC resources to fit classroom routines, with some adapting the materials to the specific needs of their students (Dorney & Erickson, 2019; Laher & Dada, 2023). In clinical and experimental settings, the interventions were more structured, maintaining consistency to evaluate the effectiveness of different doses and modalities of aided input (Hassim, 2019; Ngwira, 2019; Remner et al., 2016). This flexibility reflects the adaptability of aided augmented input across different settings and populations with ASD, emphasising the importance of context-specific adjustments. These findings also highlight the significance of prior training, particularly when interventions are implemented by professionals who are naturally part of the educational or clinical environments.

Interventions and results were described in detail in terms of frequency, duration, and a summary of the results is shown (Table 2). The interventions conducted in these studies meet the criteria proposed by Goossens and Crain (1986). Most studies used autism behaviour checklists (Schlosser et al., 2013; Remner et al., 2016; Finke et al., 2017; Brady et al., 2015; McFadden, Kamps & Heitzman-Powell, 2014; Kasari et al., 2014; Trottier, Kamp & Mirenda, 2011; Lorah, Karnes & Speight, 2015), which are based on observable behaviours recorded by the authors during assessment moments in the study.

Table 2. Synthesis of interventions and results

	Intervention	Frequency and duration	Summary of results
Allen et al. (2021)	EG: Spoken directives, dynamic (video) and static (image) scene cues	Intervention sessions (unspecified)	Greater precision in following directives (comprehension
Brady et al. (2015)	EG: Interactive routines, physical prompts, and corrective feedback	17-76 sessions 45-60 minutes	Increased production of spoken words
Dorney & Erickson (2019)	EG: PCS CG: PECS system	5 days x 7 months 15-45 minutes	Abstract graphic symbols increased social engagement and information sharing
Emerson & Dearden (2013)	EG: Identification of elements and opportunities for social participation and responding by pointing	32 sessions 20 months 20-30 minutes	Improved understanding of complex language and literacy skills
Finke et al. (2017)	EG: Communication screens with multi-symbol messages based on favourite books	14 weeks	Improved language and communication to meet daily needs
Harjusola-Webb & Robbins (2012)	EG: Strategies to promote communication (commenting, labelling, modelling, and reinforcement)	Daily sessions 18 weeks 30 minutes	Increased functional skills without interrupting classroom activities
Hassim (2019)	EG: 60% aided augmented input level CG: 20% aided augmented input level	Intervention sessions (unspecified) 20 minutes	60% aided augmented input produced greater response accuracy and increased communication modes
Kasari et al. (2014)	EG: JASP+EMT+SGD CG: JASP+EMT	24 sessions 6 months 60 minutes	Significant advances in spontaneous communication through joint participation, play skills, and SGD use
Laher & Dada (2023)	EG: Aided augmented input with 70% dose CG: Aided augmented input with 40% dose	10 sessions 10 days 20 minutes	Using a low-tech AAC board at a 70% dose increased receptive vocabulary and language skills

Table 2. Continued.

	Intervention	Frequency and duration	Summary of results
Lorah, Karnes & Speight (2015)	EG: Instructions represented with three specific symbols and two distractor symbols	2 sessions 12 weeks 2 hours	Responded to three intraverbal statements and acquired skills rapidly
McFadden, Kamps & Heitzman-Powell (2014)	EG: Bringing participants and peers together for interactive games and activities	17-37 sessions 7 months 20-30 minutes	Significant increases in social communication with peers and generalisation of these skills
Muttiah et al. (2022)	EG: VSDs with interactive "hotspots" for people, objects, and events, combined with aided modelling in natural contexts	1-2 times per week 2-4 weeks 10-15 minutes	Significant increases in communication turns and unique semantic concepts; supported preliminary efficacy for communicative engagement
Ngwira (2019)	EG: 75% aided augmented input level CG: 25% aided augmented input level	Intervention sessions (unspecified) 15 minutes	Aided augmented input benefitted participants in both conditions
Park, Moulton & Laugeson (2023)	EG: Developmentally appropriate social skills with parent involvement and behavioural strategies integrated into play-based activities	5 days 16 weeks 15-20 minutes	Improvements in social responsiveness, cognition, motivation, and reductions in restricted, repetitive behaviours
Remner et al. (2016)	EG1: Verbal speech combined with static scene (image) EG2: Verbal speech with dynamic scene (video) CG: verbal discourse	Intervention sessions (unspecified) 30 minutes	Visual aids (static or dynamic) improved children's ability to follow verbal directives (comprehension)
Schlosser et al. (2013)	EG1: Dynamic scene (video) EG2: Static scene (image) CG: Spoken interaction	6 months	Combining static and dynamic scene cues with speech was more effective than using speech alone
Trottier, Kamp & Mirenda (2011)	EG: SGD devices to engage in peer interactions in school	13 sessions 86-130 minutes	Improvements in social interactions after AAC instruction

Note: EG: Experimental Group; CG: Control Group; EMT: Enhanced Milieu Teaching; JASP: Joint Attention Symbolic Play Engagement and Regulation; SGD: Speech-Generating Device; PCS: Pictographic Communication System; PECS: Picture Exchange Communication System; AAC: Augmentative and Alternative Communication; VSDs: Visual Scene Displays.

Checklists allow for participant profiling and tracking their progress in communication, social, or behavioural areas. In addition, the standardised Childhood Autism Rating Scale (CARS; Schopler, Reichler & Renner, 2010) and the Peabody Picture Vocabulary Test Fourth Edition (PPVT-4; Dunn & Dunn, 2007) were used in three studies (Allen et al., 2021; Hassim, 2019; Ngwira, 2029) for primary measures. Harjusola-Webb and Robbins (2012) and Brady et al. (2015) used the Vineland II Adaptive Behaviour Scales (Sparrow, Cicchetti & Balla, 2005). An observational survey test was used by Laher and Dada (2023) to measure participant progress. Additionally, Muttiah et al. (2022) assessed participants' communication skills using the Communication Matrix (Rowland, 2013). In this study, teachers, paraprofessionals, or caregivers provided information about the children and also completed the M-CDI (Fenson et al., 2007) to evaluate expressive vocabulary. Park, Moulton and Laugeson (2023) included the Program for the Education and Enrichment of Relational Skills (PEERS) and ADOS-2 among their assessment tools.

Implications for receptive and expressive communication

Across the included studies, several consistent patterns emerge regarding the effects of aided augmented input on receptive and expressive communication. First, the integration of visual supports with spoken language systematically improves directive-following accuracy, particularly for abstract linguistic structures such as prepositions (Schlosser et al., 2013; Remner et al., 2016; Allen et al., 2021). Second, higher dosages of aided augmented input tend to yield stronger outcomes in both receptive and expressive domains, as evidenced by studies manipulating modelling density (Hassim, 2019; Laher & Dada, 2023; Ngwira, 2019). Third, interventions that embed aided input within naturalistic and interactive contexts appear to promote not only comprehension but also expressive outcomes such as vocabulary acquisition, multi-symbol message production, and increased communicative turns (Dorney & Erickson, 2019; Brady et al., 2015; Muttiah et al., 2022; Finke et al., 2017).

At the same time, some divergences are evident. For example, while several studies report comparable effectiveness between static and dynamic visual supports (Schlosser et al., 2013; Remner et al., 2016), the relative advantage of each modality may depend on individual learner characteristics and task demands (Allen et al., 2021). Similarly, responsiveness to intervention varies according to baseline language abilities, with some participants demonstrating more substantial gains than others in expressive outcomes (Brady et al., 2015), suggesting that aided augmented input may not benefit all profiles equally without appropriate individualisation.

To enhance clarity, studies in this section are organised thematically according to their primary outcome focus: (a) directive comprehension and receptive language (e.g., Schlosser et al., 2013; Remner et al., 2016; Allen et al., 2021), (b) effects of input dosage (e.g., Hassim, 2019; Laher & Dada, 2023; Ngwira, 2019), and (c) expressive communication and multi-symbol production within naturalistic contexts (e.g., Brady et al., 2015; Dorney & Erickson, 2019; Muttiah et al., 2022).

Schlosser et al. established the foundational experimental conditions that have since become the most frequently replicated in subsequent research. They provided a pivotal study on aided augmented input by comparing three instructional modalities: oral input alone, oral input paired with static scene cues (images), and oral input paired with dynamic scene cues (videos). Their research focused on children with ASD or pervasive developmental disorders-not otherwise specified (PDD-NOS) to evaluate their ability to follow directives involving prepositional phrases such as “Put the boy under the lamp”. The results demonstrated that static and dynamic scene cues significantly outperformed spoken input alone, with accuracy rates of 83% and 81%, respectively, compared to 19% for spoken input.

Dynamic scene cues displayed the complete motion of placing an object in its final spatial position relative to another, while static scene cues captured only the final position. Both modalities enhanced comprehension by providing additional visual context, allowing children to better interpret the relationships described in the directives. Interestingly, there was no statistically significant difference between the static and dynamic scene cues, suggesting that the choice of modality can be flexible depending on instructional preferences and resources available.

The study highlighted the limitations of spoken input alone for children with ASD, who often struggle with auditory processing and transient cues. By integrating visual modalities, educators and clinicians can provide more permanent and accessible instructional supports. The findings advocate for the inclusion of static or dynamic visual supports in both educational and therapeutic contexts to enhance directive-following and spatial understanding.

Remner et al. (2016) replicated and expanded upon the foundational work of Schlosser et al. (2013) by exploring the effects of static and dynamic scene cues combined with oral directives on comprehension in children with moderate to severe ASD. This study focused on improving understanding of prepositional phrases such as “put the block on the box” or “put the block behind the box” using aided augmented input strategies. The study utilised ten participants aged 9–20 years, all diagnosed with ASD and exhibiting profound deficits in receptive vocabulary skills, as measured by the Receptive One-Word Picture Vocabulary Test (ROWPVT-4). The intervention involved three conditions: a) verbal input alone (e.g., “Put the block on the box”); b) verbal input paired with static scene cues, which depicted the correct spatial relationships as a photograph; and c) verbal input paired with dynamic scene cues, which presented the spatial relationships as a video sequence.

Stimuli included a wooden block and two boxes, and directives targeted seven prepositions (e.g., “in”, “on”, “under”, “between”). Visual cues were displayed on an iPad™, chosen for its capacity to maintain participants' motivation and attention. Participants were tested in randomised sequences during two separate sessions to ensure response stability. The study revealed significant improvements in directive comprehension when visual cues were included. Interestingly, while both static and dynamic cues were effective, no statistically significant difference was observed between the two visual modalities. However, some participants demonstrated a clear preference for dynamic cues, suggesting individual variability in modality effectiveness.

The findings highlight the critical role of visual supports in enhancing language comprehension for people with ASD, particularly for abstract concepts like prepositions. The study emphasises that mere repetition of verbal instructions does not yield the same benefits as aided augmented input strategies, underscoring the importance of integrating multimodal supports into therapeutic and educational settings.

Hassim (2019) and Ngwira (2019) explored the effects of varying doses of aided augmented input. Both studies highlight the importance of visual supports in complementing oral directives for children with ASD, especially in tasks requiring comprehension of abstract concepts. They emphasise the need to consider individual variability in response to input dosage, suggesting that single-input approaches may be insufficient.

Hassim (2019) investigated the effects of varied dosages of aided augmented input on following directives containing prepositions in children with ASD. This study used a within-subject crossover design to expose participants, aged 5 to 11 years, to two conditions of aided input dosage: 20% and 60%. Participants completed pre-tests assessing their noun and preposition knowledge and matching skills to ensure they met the inclusion criteria.

The intervention employed Go Talk Now™ software, presenting Picture Communication Symbols (PCS) alongside spoken directives. For example, participants were instructed to “Put the spoon under the bowl”, with PCS symbols displayed in varying frequencies depending on the dosage condition. Results indicated that a higher dosage of aided input (60%) yielded greater accuracy in directive comprehension for most participants, with some exceptions. Nine participants showed better performance at the higher dosage, while four performed better at the lower dosage, highlighting the need for individualised approaches. Additionally, five participants responded equally across conditions, and three did not respond at all. These results underline the potential benefits of tailored input dosages in enhancing receptive language skills.

Ngwira (2019) conducted a similar study focusing on the use of aided augmented input to improve directive comprehension in children with ASD. This research employed real-colour photographs instead of PCS symbols, integrated into a naturalistic play-based intervention. The study emphasised varying the frequency of visual and verbal cues. The findings mirrored Hassim's results, confirming that a higher dosage of visual input generally led to improved accuracy in following directives, particularly for spatial relationships involving prepositions such as “on”, “under”, and “beside”.

Allen et al. (2021) investigated the effects of different types of visual and oral cue combinations on directive-following accuracy in ASD children, aged 4 to 10 years, with moderate-to-severe communication challenges. The study employed three instructional modalities: a) spoken input alone (SPO), participants were given verbal directives without accompanying visual aids; b) dynamic scene cues combined with spoken input (SC), with short video clips demonstrated the spatial relationships depicted in the directives (e.g., placing a figurine “behind” an object); and c) element cues paired with spoken input (EC), with static sequences of graphic symbols representing nouns, prepositions, and objects were presented. This research focused on how integrating various visual supports with oral input could enhance the comprehension of spatial prepositions in directive-following tasks.

Participants were pre-screened for basic match-to-sample (MTS) skills and receptive vocabulary. The intervention was conducted in their homes in a controlled setting to minimise distractions. Visual and oral cues were presented using an iPad™. The study revealed significant differences in directive-following accuracy across conditions. The SC condition resulted in the highest accuracy and was significantly more effective than both SPO and EC conditions. Interestingly, the study found a positive correlation between participants' pre-existing spoken noun knowledge and their performance in the SC condition. This suggests that dynamic scene cues may activate and leverage semantic networks associated with known vocabulary.

This study supports the efficacy of dynamic scene cues as a tool for enhancing directive comprehension in children with ASD. Unlike static element cues, which require participants to interpret syntactic relationships, dynamic scene cues explicitly depict these relationships, making them more accessible for people with limited receptive language skills.

Laher and Dada (2023) conducted a study investigating the impact of an intervention based on aided augmented input on receptive vocabulary acquisition in children with complex communication needs and severe intellectual disabilities, including those with ASD. The intervention utilised communication boards measuring 50 x 70 cm, each displaying 10 x 10 cm coloured pictographic symbols created with Boardmaker Plus v6.1.6 software. During tailored activities, the researcher guided participants by pointing to these symbols while articulating the corresponding words, thereby providing augmented input to facilitate language learning. The intervention compared two dosages of aided augmented input: 40% and 70%. Receptive vocabulary acquisition was assessed to determine the effectiveness of each dosage level.

The results indicated that all participants demonstrated receptive vocabulary acquisition when aided augmented input was provided at a 70% dosage. In contrast, only two participants showed vocabulary gains at the 40% dosage level. These findings suggest that a higher dosage of augmented input may be more effective in facilitating receptive vocabulary acquisition for children with complex communication needs and severe intellectual disabilities, including those with ASD. Additionally, the acquired vocabulary was maintained following a six-day withdrawal period, indicating the intervention's potential for promoting lasting language gains.

This study underscores the importance of dosage in the application of aided augmented input interventions, as noted previously by Hassim (2019) and Ngwira (2019). Laher and Dada (2023) demonstrated that utilising communication boards with pictographic symbols, combined with a higher dosage of aided augmented input, effectively improves receptive vocabulary in children with severe intellectual disabilities and complex communication needs, including those with ASD.

Finke et al. (2017) demonstrated the effectiveness of aided augmented input in combination with a least-to-most prompting (LTM) procedure to enhance multi-symbol message production in children with ASD who relied on AAC. The intervention focused on integrating aided augmented input during interactive book-reading activities to support language and communication development. The study involved six children aged 8 to 12 years who used AAC devices. During the intervention, the Proloquo2Go™ software was used to present multi-symbol messages alongside spoken language, aligning with the principles of the strategy intervention. The LTM procedure added a structured hierarchy of prompts—starting with minimal assistance and progressing to more explicit guidance—to encourage children to construct messages with two or more symbols. The intervention emphasised modelling, where the facilitator combined verbal input with the visual display of symbols to reinforce language learning.

The results indicated a consistent increase in the production of multi-symbol messages across all participants following the introduction of aided augmented input and LTM strategies. This approach also fostered greater attention and engagement during book-reading sessions. The study highlights the potential of the strategy to support multi-symbol communication and its role in promoting meaningful language interactions for children with ASD who use AAC.

Similarly, Harjusola-Webb and Robbins (2012) explored the impact of aided augmented input in naturalistic interventions implemented by teachers to enhance communication in preschoolers with ASD. Teachers received training on implementing aided augmented input strategies such as combining spoken language with gestures, pointing to visual supports (e.g., pictograms), and modelling communication during child-led activities. The intervention was tailored to the children's individual interests, with teachers using aided augmented input to respond to and expand on the children's communicative attempts.

The study found that aided augmented input strategies increased opportunities for communication and resulted in a significant improvement in expressive communication among the children. Teachers' consistent use of these techniques, such as pointing to symbols while speaking, created a supportive linguistic environment that allowed children to connect visual and verbal inputs. This approach facilitated natural communication exchanges without disrupting the flow of classroom routines, demonstrating the feasibility and effectiveness of aided augmented input in educational settings.

Emerson and Dearden (2013) conducted a case study focusing on a 10-year-old non-verbal boy with ASD to assess the impact of using "full" language within the framework of the "least dangerous assumption". This educational philosophy posits that, in the absence of conclusive data, educators should make assumptions that, if incorrect, will have the least harmful effect on the student. In this context, it involves presuming competence and providing rich language input, even when a child's receptive language abilities are uncertain.

The intervention employed aided augmented input strategies to enhance comprehension, literacy, and motivation. Engaging resources such as matching images with words, spelling exercises, and sentence formation tasks were utilised. The researchers (speech therapists) provided "full" language input by using complete sentences and a rich vocabulary, rather than simplifying language or relying solely on minimal speech approaches.

The study revealed that the child demonstrated improved comprehension and vocabulary acquisition following the intervention. These findings suggest that providing rich language input, even to non-verbal children with ASD, can facilitate language development and literacy skills. The results challenge the assumption that children with limited expressive abilities cannot benefit from complex language exposure. This case study underscores the importance of adopting the "least dangerous assumption" by presuming competence and providing enriched language input to children with ASD, regardless of their expressive language abilities. Educators and practitioners are encouraged to utilise aided augmented input strategies and avoid underestimating the potential of non-verbal children. By offering comprehensive language exposure, there is potential to enhance comprehension, literacy, and overall communication skills in this population.

Similarly, Dorney and Erickson (2019) explored the impact of a classroom-based AAC intervention on preschool students with ASD. The intervention incorporated three evidence-based, transactional approaches: a) attributing communicative meaning to student behaviours; b) providing aided augmented input; and c) focusing on graphic symbols representing core vocabulary. Data collection methods included observation field notes, Individualised Education Programs (IEPs), and direct communication assessments. The researchers aimed to explore interaction patterns between educators and students while analysing improvements in student communication, as measured by the Communication Matrix.

The results indicated a transactional relationship between educators' and students' communication across the classrooms. Specifically, the preschool students learned to use abstract graphic symbols representing core vocabulary to make requests, a development attributed to the educators' focus on this communicative function. Additionally, several students demonstrated growth in the use of non-verbal communication for social interaction and information sharing, which was associated with the educators' increased use of aided augmented input.

This study highlights the potential of using graphic symbols to teach requesting and basic vocabulary to children with ASD, thereby fostering functional communication for specific purposes. The findings suggest that educators' intentional focus on aided augmented input and the use of core vocabulary symbols can effectively enhance communication skills in preschool students with ASD.

Brady et al. (2015) conducted a pilot study to evaluate a multimodal intervention aimed at enhancing expressive word learning in school-age children with ASD, aged 6 to 10 years, who have limited expressive vocabularies. The intervention combined speech sound practice with AAC strategies to teach individualised vocabulary words. These words were selected based on each child's existing speech sound repertoire and principles of phonotactic probability.

The intervention utilised Proloquo2Go™ software to provide visual models and interactive routines, accompanied by physical prompts such as pointing and corrective feedback. The results indicated that five children, termed “High Responders”, demonstrated significant gains in spoken-word learning across successive word sets. The remaining five children, labelled “Low Responders”, did not meet the learning criteria. Comparative analyses revealed that High Responders had relatively higher skills in receptive language, imitation, and oral motor abilities prior to the intervention.

This study supports the efficacy of combining oral and visual input through multimodal interventions to promote effective communication in children with ASD across diverse contexts. The findings suggest that integrating speech sound practice with AAC resources can enhance the production of spoken words, particularly in children with certain pre-existing skills. However, further research is recommended to explore the factors influencing the varying responsiveness of children with ASD to such resources, using an intervention based on aided augmented input.

Muttiah et al. (2022) investigated the use of low-tech Visual Scene Displays (VSDs) combined with aided augmented input in naturalistic contexts. The intervention focused on three preschool-aged children with ASD at a presymbolic level of communication. The VSDs featured interactive “hotspots” representing people, objects, and events, which were paired with spoken input during interactive play sessions.

The results demonstrated significant increases in the number of communication turns and unique semantic concepts expressed by the participants. For example, one participant increased from 0-7 communication turns at baseline to 20-28 turns during intervention sessions. This study highlighted the effectiveness of combining oral input with visual elements in creating meaningful communicative opportunities, emphasising the potential of low-tech solutions for populations with complex communication needs. These findings align with previous research (e.g., Schlosser et al., 2013; Hassim, 2019) that supports the use of multimodal strategies to enhance receptive and expressive language skills, while also underscoring the feasibility of applying aided augmented input in naturalistic settings.

Implications for social and behavioural skills

This section synthesises studies in which aided augmented input was associated with changes in broader social participation, peer interaction, motivation, and behavioural outcomes. Although communication gains often co-occurred, the emphasis here is on socially mediated and behavioural dimensions beyond discrete language measures. In this context, Park, Moulton and Laugeson (2023) evaluated the impact of aided augmented input on social skills in children with ASD through structured didactic lessons, role-playing scenarios, and behavioural learning activities. They conducted a study evaluating the effectiveness of the Program for the Education and Enrichment of Relational Skills (PEERS®) for Preschoolers, a parent-assisted social skills training program tailored for young children with ASD. The intervention was designed to address the challenges children with ASD face in forming reciprocal friendships by enhancing their social functioning through developmentally appropriate strategies.

The study involved a two-part evaluation of the PEERS® for Preschoolers program. Modifications to the original PEERS® curriculum included the incorporation of developmentally appropriate social skills, increased parental involvement, and the integration of behavioural strategies within play-based activities. Parents were actively engaged in the intervention, facilitating the generalisation of skills to naturalistic settings.

The intervention led to significant improvements in several areas: a) social responsiveness: enhanced ability to engage in social interactions; b) social cognition: improved understanding of social cues and contexts; and c) social motivation: increased willingness to participate in social activities. Additionally, there were notable reductions in: a) restricted and repetitive behaviours: decreased engagement in repetitive actions or adherence to rigid routines; and b) problem behaviours: reduction in behaviours that interfere with daily functioning and social interactions.

Previously, McFadden, Kamps and Heitzman-Powell (2014) highlighted the role of group play as a key strategy for fostering social and communication skills of children with ASD, aged 6 to 8 years. The intervention incorporated several evidence-based social skills-teaching procedures, including direct instruction, priming, prompting, peer mediation, contingent reinforcement, and token economies, directly in the recess setting to increase appropriate social behaviours. Elements of Peer Networks and Pivotal Response Training were included.

The intervention was implemented during recess, a naturalistic and less structured environment, to promote the generalisation of social skills. The program included class-wide social skills lessons, priming, adult prompting and feedback, peer prompting and praise, and a token economy. Peers were trained to model, initiate, prompt, and reinforce social behaviours and interactions with the target children.

The results demonstrated significant increases in social communication between focus children and their peers. Notably, the children with ASD were able to generalise their improved social skills to non-intervention recesses, indicating the effectiveness of the intervention in promoting lasting behavioural changes. The study also observed a reduction in behavioural challenges during recess, suggesting that enhanced social interactions contributed to better overall behaviour in less structured settings.

In summary, the evidence suggests that aided augmented input may contribute to improvements in social participation and behavioural regulation, particularly when embedded within interactive and peer-mediated contexts. Across studies, gains in social responsiveness, peer interaction, and reductions in problem behaviours appear to be closely linked to enhanced communicative competence. These findings support the view that communication and social behaviour are functionally interconnected, and that interventions targeting symbolic communication may have broader developmental effects beyond language itself. However, the limited number of studies explicitly addressing these outcomes highlights the need for more systematic investigation in this domain.

Aided augmented input combined with speech-generating devices

Several studies (Kasari et al. 2014; Lorah, Karnes & Speight, 2015; Trottier, Kamp & Mirenda¸2011) incorporated Speech-Generating Devices (SGDs) into aided augmented input interventions. Kasari et al. (2014) conducted a study to evaluate the effectiveness of communication interventions for minimally verbal children with ASD, aged 5 to 8 years. The research focused on the use of SGDs within naturalistic communication settings to enhance spontaneous language use, based on the aided augmented input strategy. Participants were randomised to receive a blended developmental and behavioural intervention, specifically Joint Attention, Symbolic Play, Engagement, and Regulation (JASP+EMT), either with or without the addition of an SGD. In the first stage, all children received two sessions per week for three months. In the second stage, the intervention was adapted based on the child's early response, either by increasing the number of sessions or by adding the SGD.

The results indicated that children who received the intervention with the SGD (JASP+EMT+SGD) demonstrated significant improvements in spontaneous communicative utterances, the use of novel words, and the frequency of comments, compared to those who received the intervention without the SGD. The study also found that starting the intervention with the SGD and intensifying it for children who were slow responders led to better post-treatment outcomes.

This study suggests that incorporating SGDs can effectively enhance language development in minimally verbal children with ASD. The use of SGDs, combined with strategies focusing on joint attention and symbolic play, can expand children's expressive capabilities and increase spontaneous communication within relatively short periods. These findings support the integration of aided augmented input in interventions aimed at improving communication skills in this population.

Trottier, Kamp and Mirenda (2011) demonstrated that SGD use enhanced social interactions and AAC instruction. Participants with limited verbal abilities initially struggled to produce more than 20 words, but by the end of the intervention, they increased their communicative acts and social skills. Lorah, Karnes and Speight (2015) extended this work by using iPads™ equipped with Proloquo2Go™. Their intervention, which included verbal prompts and pictograms, improved participants' ability to respond to specific social cues, highlighting the versatility of SGDs in teaching social communication skills.

DISCUSSION

This scoping review mapped the empirical evidence on aided augmented input interventions for children and adolescents with ASD who have complex communication needs—that is, significant difficulties engaging in functional communicative exchanges through spoken language, manual signs, or written modalities (Calleja & Rodríguez, 2018; Moorcroft, Scarinci, & Meyer, 2018). Across a range of research designs and service delivery contexts, studies consistently documented improvements in directive-following accuracy, receptive vocabulary, multi-symbol message production, spontaneous communicative turns, and social engagement. Importantly, the convergence of findings across both low-tech and high-tech AAC systems reinforces the robustness of aided augmented input as a mediated modelling strategy.

In a variety of research designs and service delivery contexts, studies have consistently documented improvements in directive-following accuracy, receptive vocabulary, multi-symbol message production, spontaneous communicative turns, and social engagement. Evidence spans a continuum of AAC supports, ranging from paper-based pictographic systems (e.g., Schlosser et al., 2013; Remner et al., 2016; Allen et al., 2021; Laher & Dada, 2023; Harjusola-Webb & Robbins, 2012; Emerson & Dearden, 2013; Dorney & Erickson, 2019; Park, Moulton, & Laugeson, 2023; McFadden, Kamps, & Heitzman-Powell, 2014; Muttiah et al., 2022), to Information and Communications Technology (ICT) based software applications (Brady et al., 2015; Finke et al., 2017; Hassim, 2019; Ngwira, 2019), and SGDs devices (Kasari et al., 2014; Lorah, Karnes, & Speight, 2015; Trottier, Kamp, & Mirenda, 2011). Importantly, the convergence of findings across both low-tech and high-tech AAC modalities strengthens confidence in the robustness of aided augmented input as a mediated modelling strategy.

From a theoretical standpoint, the effectiveness of aided augmented input can be interpreted within multimodal processing frameworks and transactional models of communication (Sennott, Light, & McNaughton, 2016). By pairing spoken language with stable visual-symbolic representations, this approach may reduce the cognitive demands associated with transient auditory input while facilitating symbol–referent mapping. Such mechanisms may be particularly relevant for individuals with ASD, who often demonstrate relative strengths in visual processing alongside challenges in auditory-temporal integration (Ganz et al., 2012; Light & McNaughton, 2014).

The findings of this review further extend current knowledge in several ways. First, the evidence supports the effectiveness of aided augmented input for children and adolescents with ASD and complex communication needs, confirming its applicability across a heterogeneous population profile. Second, the analysed studies suggest that many participants with ASD rely on visual supports to enhance comprehension at both lexical and sentence levels, as well as to improve accuracy in following spoken directives (Laher & Dada, 2023; Schlosser et al., 2013). Additionally, intervention success appears closely linked to individualised customisation, consistent AAC support, and the use of systematic reinforcement strategies (Scarcella et al., 2023). Taken together, these findings align with earlier research indicating that aided augmented input constitutes a highly beneficial instructional approach for facilitating the association between symbolic representations and spoken input, thereby supporting meaning-making processes grounded in the interlocutor's verbal models (Drager et al., 2006).

Finally, the results of the review also highlight reductions in problem behaviours and improvements in social development. These outcomes may be explained by the functional relationship between communication and behaviour: when individuals with ASD gain more effective ways to express needs, preferences, and affect, they are less likely to rely on challenging behaviours that serve communicative functions (Alakhzami & Chitiyo, 2022; Blair, Park & Risse, 2025). At the same time, aided augmented input may enhance reciprocal interaction, joint attention, and peer engagement because modelling accessible symbolic language supports shared reference and participation in social routines, which are core components of socio-communicative competence (Edgar, Schlosser & Koul, 2024). Additionally, interventions based on aided augmented input can have positive effects on message production and new vocabulary acquisition, sometimes resulting in generalisation of these gains to natural contexts in which users operate (Brady et al., 2015).

Limitations

Several limitations should be considered when interpreting the findings of this scoping review. First, although the 17 studies analysed spanned four countries, their geographical distribution was limited. For instance, the review did not identify any studies from Spanish or Portuguese-speaking contexts. This gap may reflect a scarcity of published research in these regions and restricts the cross-cultural generalisability of the findings, despite the growing international recognition of aided augmented input as an intervention approach.

Second, the inherent heterogeneity of ASD (Mottron & Bzdok, 2020), combined with variability in educational and clinical service delivery systems across countries, complicates the formulation of definitive conclusions. Although positive outcomes were consistently reported, differences in participant characteristics—such as verbal status, intellectual functioning, and prior AAC experience (Brady et al., 2015; Finke et al., 2017)—as well as contextual variables and implementation practices (Dorney & Erickson, 2019; Harjusola-Webb & Robbins, 2012) limit the extent to which results can be generalised. In addition, most studies included small samples, and several relied on single-case designs with one or very few participants (e.g., Emerson & Dearden, 2013; Lorah, Karnes, & Speight, 2015; Trottier, Kamp, & Mirenda, 2011). While this is common and methodologically appropriate in AAC research (Biggs, Carter & Gilson, 2018), small sample sizes inevitably constrain external validity. At the same time, recruitment challenges are understandable given the diversity of diagnoses, age ranges, communicative profiles, and levels of support needs required to meet inclusion criteria.

A further limitation concerns the heterogeneity of outcome measures. The reviewed studies employed a wide range of observational checklists (e.g., Schlosser et al., 2013; Remner et al., 2016), standardised assessments such as the CARS or PPVT-4 (Allen et al., 2021; Hassim, 2019; Ngwira, 2019), and researcher-developed probes tailored to specific intervention targets (Brady et al., 2015; Laher & Dada, 2023). This variability limited direct comparability across studies and precluded the possibility of conducting a quantitative meta-analytic synthesis. Intervention fidelity was also inconsistently reported. Although some studies described modelling procedures in detail (e.g., Schlosser et al., 2013; Muttiah et al., 2022), only a minority quantified the exact proportion of aided models delivered or systematically verified adherence to modelling protocols. The absence of detailed fidelity data makes it difficult to determine which specific components of the intervention are responsible for the reported gains and limits replication efforts.

Implications

Building on the reviewed evidence, the findings of this scoping review point toward a set of interrelated and testable research directions that can help advance the field beyond descriptive accounts of effectiveness. A central issue concerns the role of input dosage, as several studies suggest that more intensive exposure to aided augmented input may be associated with stronger gains in both receptive and expressive language. Future research would benefit from systematically manipulating modelling density to determine whether there are threshold effects or optimal dosage ranges, while also accounting for individual variability in responsiveness.

Closely related to this, the variability observed across AAC modalities highlights the need for more fine-grained comparative research. Although both static and dynamic visual supports appear to facilitate language development, their relative effectiveness may depend on the linguistic target, task demands, and learner characteristics. Investigating how different AAC formats support specific aspects of language (e.g., spatial relations or multi-symbol production) could provide more precise guidance for intervention design, particularly for children with lower baseline receptive abilities.

Another key direction involves the temporal dimension of intervention effects. The predominance of short- to medium-term studies limits our understanding of whether early improvements in symbolic communication are maintained over time and whether they generalise to broader domains such as social participation and behavioural regulation. Longitudinal approaches are therefore needed to examine developmental trajectories and to clarify the extent to which early communication gains translate into sustained functional outcomes.

These research priorities are particularly relevant in the context of ASD, where AAC plays a critical role across clinical, educational, and social settings (Holyfield et al., 2017; Llaneza et al., 2010). The diversity of AAC systems and their design features can substantially influence user performance and learning outcomes (Agius, Stansfield & Murray, 2024; Lorah et al., 2022), underscoring the importance of identifying not only whether aided augmented input is effective, but under which conditions and for whom. In this sense, the variability observed across studies reinforces the need to move away from a "one-size-fits-all" perspective and toward more individualised and context-sensitive intervention approaches.

In line with this, the evidence consistently suggests that aided augmented input is most effective when embedded within naturalistic and interactive contexts, where visual supports are integrated with spoken language to facilitate both comprehension and expression. These conditions appear to promote not only language development but also broader outcomes related to social interaction and behavioural adjustment, supporting the view that communication, social engagement, and behaviour are functionally interconnected domains (Salvadó et al., 2012). At the same time, the heterogeneity of participant responses indicates that intervention effects are mediated by individual characteristics, including baseline communicative abilities and access to appropriate supports.

The review also highlights several areas that remain insufficiently explored. In particular, more systematic comparisons across AAC tools are needed to determine their relative impact on learning efficiency, generalisation, and skill acquisition. Similarly, although some evidence points to positive effects on social and behavioural outcomes, these domains have not been examined as extensively or systematically as language outcomes, limiting the strength of current conclusions. Greater attention to these dimensions would provide a more comprehensive understanding of the broader developmental impact of aided augmented input.

Finally, the rapid evolution of technology introduces an additional layer of complexity, as emerging digital tools and applications may alter both the accessibility and effectiveness of aided augmented input compared to more traditional resources, such as printed pictograms. Exploring how these technological developments interact with intervention variables represents a promising avenue for future research.

Overall, the implications of this review extend beyond identifying general trends, pointing instead to the need for hypothesis-driven research that systematically examines key variables such as input dosage, modality, intervention context, and individual differences. Advancing knowledge in these areas will be essential for moving from evidence of effectiveness toward the identification of optimal and personalised implementation strategies for aided augmented input in individuals with ASD.

CONCLUSION

In conclusion, aided augmented input represents a clinically actionable and theoretically grounded intervention approach for supporting communication development in children with ASD who have complex communication needs. Across the studies reviewed, consistent positive effects were documented in receptive language accuracy, expressive vocabulary growth, multi-symbol message production, and, in several cases, reductions in challenging behaviours and improvements in social participation. These findings support the systematic incorporation of aided modelling practices across educational, clinical, and home settings, with particular emphasis on training communication partners to deliver high-density, contextually embedded modelling with documented fidelity. At the same time, the field would benefit from adequately powered randomised controlled trials, standardised reporting of dosage and fidelity variables, and longitudinal studies examining maintenance and generalisation beyond structured intervention contexts. Future research should also prioritise culturally and linguistically diverse populations, particularly in Spanish- and Portuguese-speaking countries, where empirical evidence on aided augmented input remains scarce despite widespread clinical need. By advancing methodological rigor and expanding cross-cultural representation, future investigations can better define best-practice parameters and optimise implementation guidelines for diverse service systems.

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