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Aided Augmented Input and the EC+ App in Autism Spectrum Disorder

Estimulación asistida del lenguaje y la app EC+ en el trastorno del espectro autista

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ABSTRACT

Autism spectrum disorder (ASD) significantly impacts communicative, social, and behavioral skills, especially in children with Level 3 ASD. Augmentative and alternative communication (AAC) systems can help address these challenges. Aided augmented input emerges as an AAC strategy that enhances expression and comprehension through visual and verbal inputs from the communicator. Additionally, the development of information and communication technologies (ICT) has enabled their educational and therapeutic use to support individuals with ASD, providing versatile and accessible tools that facilitate learning, interaction, and skill development. This study aims to analyze the effects of combining aided augmented input with a multimodal ICT support called EC+, compared to ARASAAC paper-based resources, on communicative, social, and behavioral skills. A quasi-experimental design was employed to compare the effects of both resources, including two groups of 6 children each, all with Level 3 ASD. The results showed significant improvements with both resources, but the ICT support proved more effective in the areas of communication and behavior. It is concluded that EC+ offers a more interactive and effective approach to enhancing the overall development of children with ASD, complementing paper-based resources in a valuable and innovative way.

RESUMEN

El trastorno del espectro autista (TEA) afecta significativamente las habilidades comunicativas, sociales y conductuales, especialmente en niños con TEA de Grado 3. Los sistemas de comunicación aumentativa y alternativa (CAA) pueden ayudar a enfrentar estos desafíos. La estimulación asistida del lenguaje surge como una estrategia de CAA que mejora la expresión y la comprensión a través de inputs visuales y orales del interlocutor. Por otra parte, el desarrollo de las tecnologías de la información y la comunicación (TIC) ha permitido su uso educativo y terapéutico para apoyar a personas con TEA, ya que proporciona herramientas versátiles y accesibles que facilitan el aprendizaje, la interacción y el desarrollo de sus habilidades. El objetivo del estudio es analizar los efectos de combinar la estimulación asistida del lenguaje con un soporte TIC multimodal llamado EC+, en comparación con recursos en papel de ARASAAC, sobre las habilidades comunicativas, sociales y conductuales. Se empleó un diseño cuasiexperimental para comparar los efectos de ambos recursos, incluyendo dos grupos de 6 niños cada uno, todos con TEA de Grado 3. Los resultados mostraron mejoras significativas con ambos recursos, pero el soporte TIC resultó más efectivo en el área de la comunicación y del comportamiento. Se concluye que EC+ ofrece un enfoque más interactivo y eficaz para mejorar el desarrollo global de los niños con TEA, y complementa los recursos en papel de manera valiosa e innovadora.

KEYWORDS | PALABRAS CLAVE

Apps, Communication Skills, Methods, Educational Technology, ICT, Autism Spectrum Disorder.
Apps, Competencias Comunicativas, Métodos, Tecnología Educativa, TIC, Trastorno del Espectro Autista.

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1. Introduction

Autism spectrum disorder (hereafter ASD) is a neurodevelopmental disorder that affects communication, social interaction and behavior (Sauer et al., 2021). According to the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) (APA, 2013), individuals with ASD can experience the disorder at three levels of severity: Grade 1 ASD indicates mild difficulties in social communication and repetitive behaviors, Grade 2 indicates moderate difficulties, and Grade 3 is associated with severe difficulties in these areas and very limited intellectual functioning. Individuals with Grade 3 ASD may show a wide range of symptoms, including impairments in verbal and nonverbal communication, difficulties in social interactions, and restricted and repetitive behaviors and interests (Lai, 2022; Martínez Rojas, 2024). Worldwide, the average prevalence of ASD is estimated to be 1 in 100 children (WHO, 2023). In Spain, the disorder affects approximately half a million people of all ages. On average, at preschool age 15 out of every 1000 children are diagnosed with ASD, while at school age the number drops to 10 out of every 1000 children (Morales-Hidalgo et al., 2018; Vázquez, 2023; Vidriales-Fernández et al., 2023).

The problems in the area of communication and language in ASD have led to the development of interventions and methodologies adapted to the idiosyncratic characteristics of this disorder. Based on the visuospatial skills of people with ASD (Cardillo, Lanfranchi, & Mammarella, 2020), augmentative and alternative communication (AAC) materials and resources have been created. AAC encompasses a wide range of tools and techniques designed to assist individuals with communication impairments, such as speech-generating devices, communication boards, symbol-based communication systems, and sign language, including pictograms or paper symbols (ASHA, 2023). Among the possible interventions using AAC, assisted language stimulation stands out as an effective method to enhance both the receptive and expressive aspects of language. This method can be described as a modeling strategy that goes beyond simple exposure to meaning, actively developing and reinforcing communicative skills through AAC with natural communication (Guamán-Rivera et al., 2024; Muttiah et al., 2022). This intervention involves the interlocutor pointing to pictographic symbols or real images (visual input) while simultaneously using verbal expression referring to the symbol (oral input). This dual input helps to create new sentence structures and modes of interaction by linking symbols with their meanings (Therrien, Light, & Pope, 2016). The main goals of assisted language stimulation include increasing vocalizations, developing response and interaction options through the use of objects and symbols. In addition, it aims to improve communicative intent and enhance both expressive and receptive language skills (Gómez Taibo & García-Eligio de la Puente, 2016).

1.1. Assisted language stimulation from an innovative approach

The development and evolution of information and communication technologies (ICT) has allowed their use in educational and therapeutic contexts both in the approach to disability and in the implementation of AAC systems (Durán Cuartero, 2021; Marsidin, 2022). ICTs include digital tools such as computers, apps, software and mobile devices, which facilitate the collection, storage, processing and transmission of information. These tools stand out for their portability, versatility, and accessibility, promoting their use among users (Aspiranti, Larwin, & Schade, 2020; Quiroga, Jaramillo, & Vanegas, 2019). Lehman (1998) already indicated that children with ASD are often attracted to ICTs because of their visual abilities. But in addition, the use of ICTs provides a structured environment that improves interaction and reduces stress, favoring anticipation of stimuli (Ntalindwa et al., 2019).

In view of the data provided so far, the question arises as to whether it is worth implementing ICT resources compatible with assisted language stimulation as innovative elements in educational intervention. According to Lozano Martínez et al. (2016), a software designed for people with ASD diagnosis must meet the following requirements: (a) be able to adapt to the individual's abilities, learning pace, developmental level, and interests; (b) present a user-friendly interface with clear organization, visual components, and multiple information formats such as text, audio, or highlighted icons; (c) allow configuration options to optimize performance, including text and visual pathway settings and different levels of difficulty; (d) structure the presentation of content to ensure comprehension and make learning a positive experience; and (e) provide adequate and motivating feedback for both successful outcomes and errors.

In recent years, numerous apps have appeared for tablets and smartphones -both for Android and iOS environments- whose purpose is to improve intervention in the areas of communication and language for people diagnosed with ASD, such as PictoTEA, José Aprende, Jocomunico, DictaPicto or the EC+ tool (Efendioglu & Durmaz, 2022; Moya Giménez, 2021; Pahisa-Solé, 2020; Quezada et al., 2023). In the present study, we chose to use the EC+ multimodal support (Table 1) because it is a free ICT resource that can support the AAC strategy of assisted language stimulation. The EC+ multimodal support (Luque et al., 2018) has been developed at the University of Malaga, and meets the criteria to be considered an innovative tool compatible with the proposed intervention strategy. EC+ was created in the framework of the European Erasmus+ Project and published on June 16, 2018. The tool includes a mobile app for installation on smartphones or tablets (iOS and Android operating systems), and an online academic portal accessible through any web browser. Its name stands for Enhancing Communication Plus, and its main objective is to improve communication and interaction for people with complex communication needs or minimally verbal people. Taking as a starting point the expressive communicative repertoire associated with a 3-year-old child and optimizing it for users with communication difficulties or minimal language skills, a specially designed linguistic corpus of some 400 terms was created. The most remarkable element of this tool is the multimodal approach to communication adopted, where information is presented mainly through visual, auditory and gestural means. It incorporates spoken words, written words, pictograms, real images and videos of sign language interpreters for each of the 400 concepts included in the corpus.

Table 1: Characteristics of EC+.

App logo	
Purpose	EC+ is an application launched in 2018 completely free of charge that offers different means for caregivers or professionals who must communicate with people who possess severe communication difficulties.
Skills developed	• Visual perception and discrimination. • Auditory perception and discrimination. • Acquisition or expansion of vocabulary and understanding of its meaning. • Development of working memory and sustained attention. • Development of language skills. • Enhance social interactions in any type of environment.
Operating system	Android and IOS
Available languages	Spanish, Catalan, English, German, German, and Dutch

To date, no studies have been found that employ language-assisted stimulation activities for individuals with ASD combined with CE+. Furthermore, there is scant research comparing these types of supports with paper-based AAC resources during interventions in these contexts (Marble-Flint, Strattman, & Schommer-Aikins, 2019). This may be attributed to the constant evolution of this field and the underutilization of these resources, due in part to a lack of understanding of their purposes (Marzal Carbonell et al., 2023).

1.2. Objectives

The general objective of this work is to determine whether the combination of assisted language stimulation with multimodal ICT support such as EC+ improves the most affected areas in children with Grade 3 ASD: communication, social skills and behavior (Velarde-Incháustegui, Ignacio-Espíritu, & Cárdenas-Soza, 2021). In this context, the following secondary objectives were raised:

- Objective 1: To evaluate the efficacy of intervention based on assisted language stimulation combined with the EC+ app compared to training with paper pictograms in improving the communicative component.
- Objective 2: Determine if there is an increase in social skills in participants with ASD using EC+ and assisted language stimulation compared to paper-based resources.

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- Objective 3: To examine whether the combined intervention of CE+ and assisted language stimulation contributes to the reduction of disruptive behaviors in individuals with ASD, compared to intervention with paper-based resources.

2. Methodology

2.1. Participants

Sample selection was purposive, focusing on participants with specific characteristics relevant to the study objectives from the province of Malaga, Spain. Initially, 20 potential participants were identified and underwent a rigorous selection process to ensure the homogeneity of the sample and the reliability of the study. Finally, 12 met the following inclusion criteria: (a) school-aged boys and girls, aged 6 to 12 years, selected for their diagnostic stability (De Pimentel, 2024) and for being a critical stage of development, leading to the acquisition of fundamental social, communicative and academic skills (Lima & Laplane, 2016); (b) with Spanish as their native language of instruction; (c) diagnosed with ASD classified as Grade 3, assessed by clinicians using DSM-5 criteria (APA, 2013); (d) with complex communication needs, evidenced by limited functional communicative exchanges through human verbal language (speech, signing or writing); (e) with low levels of language comprehension and expression; (f) able to concentrate on an activity for at least 10 minutes, as reported by teachers and caregivers; (g) without visual or hearing impairments; and (h) with parental or primary caregiver consent. These 12 participants were assigned a number in order of consultation and randomly distributed into two groups. Group A received an intervention based on assisted language stimulation using the EC+ app; while group B received the same intervention strategy with paper-based pictograms, without exposure to any ICT support or assistive technology.

Prior to the start of the study, participants were assessed to accurately document their characteristics (Table 2). The Adaptive Behavior Composite (ABC) measure of the Vineland-3 Adaptive Scale was used to measure complex communication needs, providing a comprehensive understanding of functional abilities in children with ASD (Sparrow, Cicchetti, & Saulnier, 2016). The ABC aggregates scores from the Communication, Daily Living Skills, and Socialization domains, with a percentage score of less than 1% indicating extremely limited performance. Intellectual Quotient (IQ) was measured with the TONI-4 Nonverbal Intelligence test, suitable for people with verbal, auditory or motor difficulties (Fopiano, 2021). To assess language comprehension and expression, the Protocol for the Assessment of the Linguistic Communicative Profile of People with Complex Communication Needs and Intellectual Disability (PCL-DIS-NCC) was used, which covers comprehension, variety of interlocutors, communicative functions, modes of communication and conversational topics (Calleja Reina, Luque, & Rodríguez Santos, 2021).

Table 2: Description of the Participants' Means.

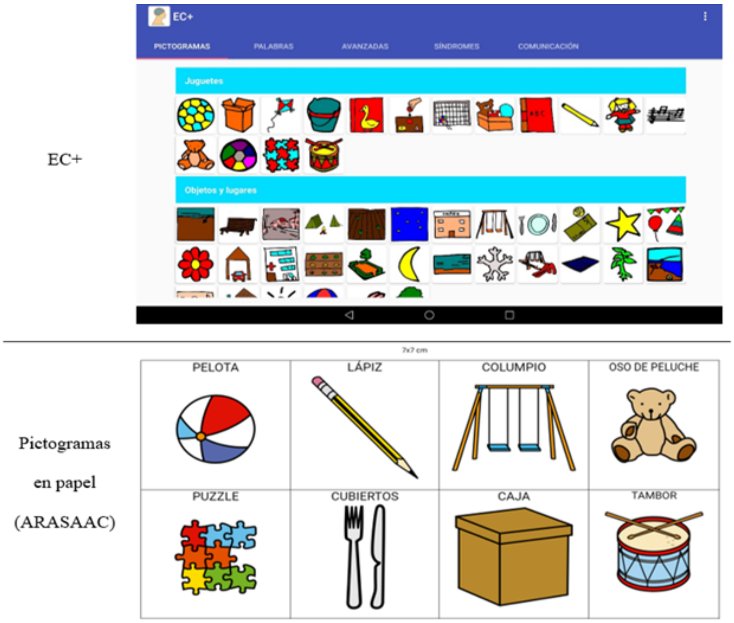
	Group A (EC+)	Group B (Pictograms on paper)
Sample size	n=6	n=6
Genre	4 male / 2 female	5 male / 1 female
Mean age and standard deviations	7.33 years (SD=1.75)	6.33 years (SD=0.81)
TONI-4 (Mean IQ and standard deviations)	65.67 (DT=4.32)	64.00 (DT=5.82)
Vineland-3 (ABC)	Percentile = <1	Percentile = <1
PCL-DIS-NCC (Mean and standard deviations)	• PCL-EC: 22.17 / 48 (DT=3.76) • PCL-EE-VI: 19.17 / 48 (DT=1.21) • PCL-EE-FC: 22 / 48 (DT= 2.50) • PCL-EE-MC: 19.83 / 48 (DT= 5.11) • PCL-EE-T: 15.5 / 48 (1.96)	• PCL-EC: 23 / 48 (DT=2.31) • PCL-EE-VI: 21.17 / 48 (DT=1.03) • PCL-EE-FC: 22.83 / 48 (DT=2.23) • PCL-EE-MC: 20.5 / 48 (DT=4.7) • PCL-EE-T: 18 / 48 (DT=2.69)

Note: IQ: Intelligence quotient; ABC: Adaptive Behavior Composite; PCL-EC: Comprehension scale; PCL-EE-VI: Variety of interlocutors; PCL-EE-FC: Communication functions; PCL-EE-MC: Communication modes; PCL-EE-T: Themes and preferences.

2.2. Materials

AAC resources based on designated pictograms were used for each group, selected for the study because of their distinctive characteristics that warranted comparison between the two (see Figure 1 for an example). Each resource presents its own set of pictograms, which meet key criteria to be considered representative and useful for people with ASD (Hervás et al., 2020).

Figure 1: Example of EC+ Interface and Paper Pictograms (ARASAAC).



For Group A, the EC+ app was selected. This app offers more than 400 specially designed pictograms with clear and colorful drawings on white backgrounds to enhance iconicity and minimize distractions (Dowse, 2021). Vocabulary terms are categorized by semantic fields: "Actions", "Food and drinks", "Animal", "Qualities", "Quantifiers and items", "Games, routines and social formulas", "Toys", "Objects and places", "Objects and places in the house", "Body parts", "People", "Prepositions and locatives", "Clothes", "Time", "Vehicles" and a last modality called "Uncategorized", where the expression of sign language is found (Luque et al., 2018). Users can enlarge pictograms and images with a single click and customize them to suit their communicative and cognitive needs. EC+ provides informative documents based on scientific evidence, including concepts of Total Communication and other pathologies. Users can adjust multimedia resources in three resolutions to improve compatibility and reduce storage usage. Words are organized into basic and advanced lists, including prepositions and determiners. The academic portal allows users to log in to edit items in the app through the web service. When the app is launched, it connects to the service to update and download resources in the selected language. The academic portal facilitates the availability of these changes in the EC+ app and allows other users to update their lists with new items (Chicano & Luque, 2017). The app was installed on a Huawei® MediaPad M5 Pro tablet with a 1920 x 1200 resolution and a 10.8-inch screen. This configuration was specifically chosen to improve the visualization of the items, facilitating effective interaction with users (Alzrayer, Banda, & Koul, 2019; Lozano Martínez et al., 2016; Yazicioglu y Kanoglu, 2022).

In Group B, pictograms were obtained from the Aragonese Augmentative and Alternative Communication Portal (ARASAAC) (Gobierno de Aragón, 2007). This offers a wide range of AAC resources covering different semantic areas and available in several languages and formats. ARASAAC pictograms stand out for their high degree of iconicity and personalization, which makes them especially effective for communication and understanding of people with ASD. In addition, they offer advanced editing options to adapt to the unique characteristics of each user (Cabello Luque & Mazón Morillas, 2018). In this study, 7x7 cm laminated pictograms printed in color on a white background were used to enhance iconicity (Dowse, 2021; Hervás et al., 2020). The pictograms included vocabulary of objects, food, clothing, people, verbs and concepts relevant to the child. Each pictogram included the corresponding written word in uppercase black letters at the top to help associate the graphic representation with the written term.

2.3. Procedure

All sessions were conducted in multidisciplinary centers, specifically in the speech therapy office.

Communication contexts included play with toys and other objects, social interaction with the interlocutor, and quantification of problem behaviors during the session. A consistent set of motivators (toys, food, and resources) was identified through preference assessments and interviews with family members prior to the study. These motivators, along with AAC supports, were strategically placed on the table to control participants' impulses and enhance the intervention strategy (Holland, Blanche, & Thompson, 2020; Wang & Li, 2024). Each week, a new item from the original set, not previously used, was introduced during the intervention periods.

The study sessions were conducted individually, lasting 15 to 30 minutes, and took place 2 to 3 times per week, depending on the availability of the participants and the center's schedule. To avoid fatigue and frustration, 5-minute breaks were strategically included after various activities. These breaks did not count toward the total intervention time, ensuring that children remained focused and engaged throughout the sessions. The intervention had a user-centered focus.

Participants sat in a chair facing a table equipped with the tablet or paper pictograms, along with relevant materials and motivators. The speech therapist was nearby to guide and facilitate the interaction, pointing to the pictographic symbols to aid comprehension and association with real-world objects or situations. The goal of this approach was to provide effective linguistic input, reinforce responses, and promote successful interactions (Holland et al., 2020; Taubaldiyev et al., 2024). Intervention through assisted language stimulation involved integrating natural social and communicative routines, such as playing with toys, engaging in activities, and interacting with the interlocutor. It was ensured that children had at least twenty opportunities to communicate during each activity, following the approach described in the study by Muttiah et al. (2022). To ensure comparison between the two groups and that there were no differences between formats, all pictograms were presented in list format.

The selected activities were compatible with both types of resources and were structured as games and joint action exercises (Hassan, Pinkwart, & Shafi, 2021). These activities addressed aspects such as awareness of the environment, emotion recognition, category classification, object discrimination, associations between two items, formulation of requests, literacy concepts, and the creation of simple sentences composed of a given article (singular and plural, masculine and feminine: "el", "la", "los", "las"), a noun and an adjective. Emotional and behavioral concepts were also introduced to prevent disruptive behaviors such as self-injury, damage to the environment and to the materials themselves (Martínez-González & López Gil, 2019).

All sessions were documented using written notes, skill checklists, and video recordings to ensure thorough recording and analysis of the procedures. The written notes provided real-time qualitative observations, while the skills checklists systematically tracked participants' progress through the various tasks. Video recordings were used for detailed analysis and verification of data accuracy. The Vineland-3 scale quantitatively assessed participants' performance at key moments.

2.4. Measurements

The information collection instrument was the Vineland-3 Scale in its Spanish version. This standardized test is an appropriate tool to measure social and communicative maturity in minimally verbal individuals and individuals with ASD (Pepperdine & McCrimmon, 2018). It assesses communication, daily living skills, socialization, motor skills, and behavior (Comprehensive Form). Scores are based on a Raw Score, which quantifies age-appropriate behaviors, with three possible response options: 2 = Usually or often; 1 = Sometimes; and 0 = Never (Sparrow et al., 2016). The Raw Score is then converted to a Scale-v Score using the corresponding scales classified by age groups (Domain-Level Form). To meet the objectives of the study, the total Scale-v Scores of the following areas were analyzed:

- Communication Range: Perception (receptive language), interpretation and transmission (expressive language) were assessed by scores on the "Listening and Understanding" (39 items), "Speaking" (49 items) and "Reading and Writing" (38 items) subtests.
- Social Rank: The user's social ability was quantified through the sum of scores of the subtests "Relationships with Others" (43 items), "Adaptive Skills" (33 items) and "Play and Use of Leisure Time" (36 items).
- Behavioral Range: Data were obtained from the "Problem Behaviors" subtest, which includes Section A (13 items), Section B (11 items), and Section C (20 items). These sections assess disruptive behaviors such as self-injury, environmental and material damage, and interference with learning (Ali, 2022; Martínez-González & López Gil, 2019). A higher score in this area indicates a greater presence of disruptive behaviors.

Following the procedures described by Pepperdine and McCrimmon (2018), the reliability of the measurements was confirmed by Cronbach's Alpha coefficient, with results indicating a satisfactory level of internal consistency and test-retest reliability for the skills assessed. None of the participants scored the highest in any of the areas assessed.

2.5. Research Design

A quasi-experimental study was conducted with two independent groups over a 16-week intervention period. The design aimed to compare both AAC resources and to determine whether EC+ produced better results by assessing participants' progression. The independent variable was the application of the assisted language stimulation strategy using pictograms from the EC+ app (ICT support) and ARASAAC (paper pictograms). The dependent variables were the scores obtained on the Vineland-3 Scale in the communication, social skills and disruptive behavior indexes. These scores were evaluated on a scale ranging from 0% (no correct answers produced independently) to 100% (5 or more correct answers produced independently), with an increase of 20 percentage points per correct answer.

Due to the number of participants, the study did not start on the same day for everyone. To address this, each participant's schedule was calculated from their baseline assessment, ensuring that everyone received the same number of intervention days and assessment times. In total, 45 sessions were conducted. The study design and the three main assessment moments were structured as follows: at Moment 1 baseline measures of Communication, Social and Behavioral Range (pre-intervention assessment) were established. From Week 2 through Week 13, Group A received EC+ assisted language stimulation, while Group B used ARASAAC pictograms (intervention period). At Time 2, participants' progress was assessed at Week 7 (interim assessment). Finally, at Time 3, a last assessment (post-intervention assessment) was performed at Week 16 after a 15-day break without training, to measure skill retention and evaluate changes in the different areas of the participants.

All procedures performed in the present study complied with the ethical standards of the institutional and national research committee, as well as with the Declaration of Helsinki and its subsequent amendments. This study has the approval of the Experimental Ethics Committee of the University of Malaga (reference number: 19-2023-H). To protect confidentiality, the personal identification data of the participants were not communicated individually.

2.6. Data Analysis

Data analysis was performed using SPSS ® Statistics version 27.0 software. The mean scores between the two groups were compared using Student's t-test and repeated measures ANOVA, considering the intersubject factor. A significance level of $p<.005$ was chosen to determine the differences between the groups. An independent observer reviewed the scores and recordings, achieving 70% agreement at Time 1. Agreement was defined when both observers identified independent or elicited responses. Interobserver reliability was calculated, averaging 90% during the intervention and maintenance sessions (Moments 2 and 3). After each session, a procedural checklist was completed, with a reliability of 95% for all three assessment moments.

3. Results

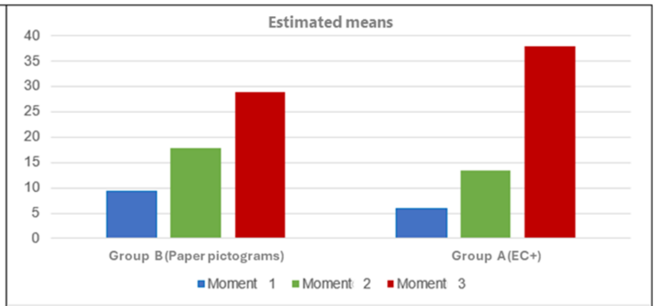
In the present study, differences were found in the components analyzed between participants who received intervention with CE+ and those who did not.

- Objective 1: To analyze the efficacy of the intervention based on assisted language stimulation in the improvement of the communicative component of Group A versus Group B.

First, performance on the Communication Range was evaluated, comparing the scores obtained according to the type of resource. Statistically significant differences were found in the measures of the adaptive behavior scale throughout the three moments evaluated. At Moment 1, a mean difference of 7.58 ($t=8.19$, $p<.005$) was observed; at Moment 2, the difference was 15.58 ($t=7.95$, $p<.005$); and at Moment 3, the mean difference reached 33.33 points ($t=15.44$, $p<.005$). In addition, the mean differences between groups A and B were analyzed. The results showed an improvement in the Communication Range of Group A of 32 points (SD=5.81) compared to 19.5 points (SD=6.36) for the control group. Figure 2 illustrates the differences between the first and the last evaluation of the participants.

Finally, a repeated measures ANOVA was performed, which revealed that the intervention combined with EC+ scored statistically significantly better than the intervention with paper pictograms that did not include ICT supports ($F_{(1.72)}=12.42$, $p<.005$, $\eta^2 = .554$, $\beta\text{-}1=.979$).

Figure 2: Comparison of Communication Range by Groups and by Time of Evaluation.

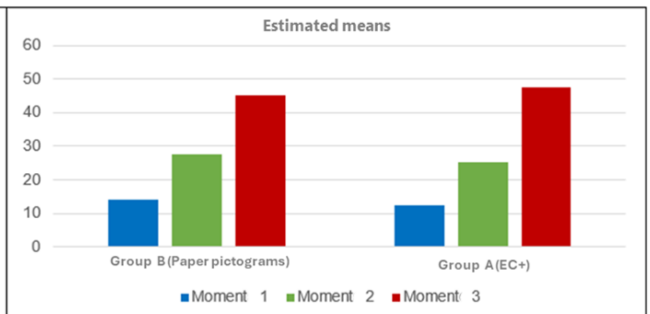


		Grupo B (Pictogramas en papel)			Grupo A (EC+)		
		Moment 1	Moment 2	Moment 3	Moment 1	Moment 2	Moment 3
Media		9.333	17.833	28.833	5.833	13.333	37.833
Error deviation		1.127	2.727	2.489	1.127	2.727	2.489
95% Confidence interval	Lower limit	6.823	11.757	23.288	3.323	7.257	32.288
	Upper limit	11.844	23.909	34.379	8.344	19.409	43.379

- Objective 2: Is a differential increase in social skills observed in participants according to the type of resource used?

To address this question, an initial analysis was conducted to determine the Social Rank among participants. Statistically significant differences were found in the developmental test measures at different evaluation moments. At Moment 1 a mean difference of 13.17 ($t=10.25$, $p<.005$) was observed; at Moment 2 the difference was 26.33 ($t=10.07$, $p<.005$); and at Moment 3 the difference reached 46.33 ($t=27.95$, $p<.005$). Subsequently, the mean differences between groups A and B were analyzed. The results indicated an improvement in Group A's mean Social Rank of 34.5 points (SD=5.98) compared to Group B's 31 points (SD=5.69). Figure 3 illustrates the differences between the participants' first and last assessments. Finally, a repeated measures ANOVA was conducted, the results of which indicated that there were no significant differences in Social Rank when comparing the two resources after 16 weeks. However, the intervention with EC+ showed slightly superior results ($F_{(1.37)}=2.65$, $p>.005$, $\eta^2 = .209$, $\beta\text{-}1=.375$).

Figure 3: Comparison of the Social Rank by Group and by Evaluation Moment.

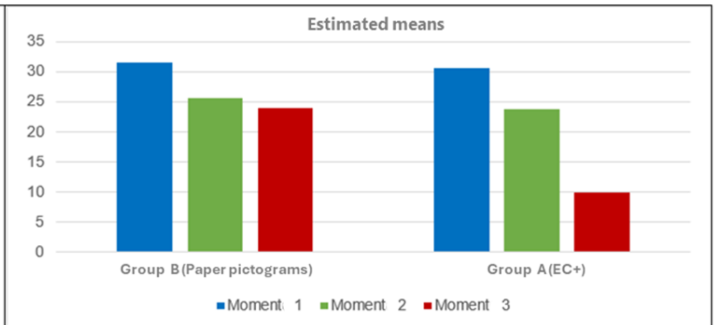


		Grupo B (Pictogramas en papel)			Grupo A (EC+)		
		Moment 1	Moment 2	Moment 3	Moment 1	Moment 3	Moment 3
Media		14.000	27.500	45.000	12.333	25.167	47.667
Error deviation		1.868	3.843	2.385	1.868	3.843	2.385
95% Confidence interval	Lower limit	9.838	18.936	39.686	8.171	16.603	42.352
	Upper limit	18.162	36.064	50.314	16.495	33.730	52.981

- Objective 3: To determine whether the combined intervention with EC+ influences the reduction of disruptive behaviors compared to the intervention with paper pictograms.

Finally, the same procedure was followed as in the previous analyses. First, an initial analysis was performed to evaluate the evolution of the Behavioral Range among participants. Significant differences were found in the developmental test measures at the three evaluation moments in both groups. At Moment 1 there was a mean difference of 31.08 ($t=14.1$, $p<.005$); at Moment 2 the difference was 24.75 ($t=11.9$, $p<.005$); and at Moment 3 the mean difference was 17 ($t=6.88$, $p<.005$). Next, the differences in means between groups A and B were analyzed, and an improvement in the mean Behavioral Range of Group A of 20.67 points ($SD=3.89$) was found versus the improvement of 7.5 points ($SD=5.32$) for Group B. Figure 4 shows the differences between the first and the last evaluation of the participants. Finally, a repeated measures ANOVA was performed. The results indicated that the intervention combined with the EC+ app produced a significant decrease in disruptive behaviors, compared to the intervention with paper pictograms, after an intervention period of 16 weeks ($F_{(2)}=26.37$, $p<.005$, $\eta^2 = .725$, $\beta\text{-}1=1$).

Figure 4: Comparison of the Behavioral Range by Groups and by Evaluation Moments.



		Grupo B (Pictogramas en papel)			Grupo A (EC+)		
		Moment 1	Moment 2	Moment 3	Moment 1	Moment 2	Moment 3
Media		31.500	25.667	24.000	30.667	23.833	10.000
Error deviation		3.263	3.056	1.906	3.263	3.056	1.906
95% Confidence interval	Lower limit	24.230	18.859	19.753	23.396	17.025	5.753
	Upper limit	38.770	32.475	28.247	37.937	30.641	14.247

4. Discussion and Conclusions

In the present study, the use of the EC+ app stands out for its multimodal nature, a feature that differentiates it from previous research in the field of ASD intervention. Multimodality, which combines visual, auditory, and tactile stimuli, offers a comprehensive approach that enhances language-assisted stimulation. This type of intervention has not yet been sufficiently explored in the literature, especially in this population, and complements existing research, which has focused on more unidimensional methods, such as the use of pictograms on paper or specific software without integrating multiple sensory modalities (Durán Cuartero, 2021; Therrien et al., 2016). These interventions, although effective, tend to be limited to a single communication channel, which may restrict their impact on improving communication, social and behavioral skills. In contrast, the use of a tool such as EC+ allows for a richer learning experience tailored to the individual needs of each user, taking advantage of the natural affinity of children with ASD for digital resources, which has been reflected in the results.

Both the intervention with paper pictograms (Group B) and the intervention combined with the EC+ app (Group A) showed improvements in the areas assessed. However, Group A had a considerable increase in the Communication Range compared to Group B, indicating greater interaction with their environment, people and surrounding elements. The use of a tablet can be particularly engaging for children, as it captures their attention more effectively than traditional paper-based methods (Marble-Flint et al., 2019). The interactive and engaging nature of the app can make learning more enjoyable, increasing the likelihood of maintaining attention, the level of engagement during activities and increasing the motivation of participants (Aspiranti et al., 2020; Marzal Carbonell et al., 2023).

Regarding the Behavioral Range, a significant difference in favor of the ICT support was also observed. Group A showed a greater reduction in disruptive behaviors compared to Group B, suggesting that the combined strategy with EC+ support has a strong impact on reducing such behaviors compared to the paper-based resource methodology. Tablet use can offer considerable behavioral benefits (Esposito et al., 2017). The structured and predictable nature of tablet activities, specifically with EC+, can provide a sense of security and routine in children with ASD, helping to maintain their focus and reduce potential instances of frustration that often lead to disruptive behaviors (Charitaki, 2015).

The absence of significant differences in the Social Range between the study groups may be explained by the effectiveness of both types of resources in promoting social interaction, although Group A has relatively higher scores. Both formats provide structured visual aids that help children with ASD understand and participate in social interactions. The systematic use of visual cues, routines, and interactive activities in both groups helps develop social skills such as eye contact, turn-taking, and communication initiation (Alzrayer et al., 2019). The individualized approach, combined with the nature of the language-assisted stimulation strategy, may explain the similar social skills outcomes observed in both groups (Hassan et al., 2021).

Some limitations of the study include the relatively small sample size. Similar to studies such as those by Esposito et al. (2017) or Marble-Flint et al. (2019), this may limit the generalizability of the results, especially considering that the ASD population is very heterogeneous, creating a wide range of communicative, cognitive, functional, and sensory profiles within the spectrum (Mottron & Bzdok, 2020). This diversity is reflected in the results of the study, where significant differences were found between groups A and B from the initial assessment. To prevent this from becoming a problem, efforts were made to make the participants in both groups as homogeneous as possible. Also, the duration of the study could be longer, to assess the sustainability of the effects of the intervention over a longer period of time.

It is important that future research focus on examining how assisted language stimulation can be adapted to other emerging educational and therapeutic contexts driven by the increasing use of educational technology. It is essential to understand the extent to which these advances can benefit individuals with ASD and how their potential benefits manifest themselves in comparison to the use of paper-based resources. ICT supports provide unprecedented opportunities for personalization and accessibility of interventions in any setting, but it is vital to explore how these new supports can be integrated into existing learning programs to complement and enhance current approaches. It should be emphasized, however, that the application of ICT should not detract from the importance of human interaction and the therapist-user relationship, as these forms of support are critical to the success of education.

The present study provides evidence describing the usefulness of combining ICT supports such as the EC+ app with the assisted language stimulation strategy. Promising results have been obtained in children with Grade 3 ASD in a Spanish-speaking context who present severe difficulties in communication, as well as in social and behavioral areas, thus confirming the advantages of this technological resource. In conclusion, the results highlight the value of integrating this type of support by providing an interactive and effective approach to enhance the overall development of children with ASD. This integration can serve as a valuable complement to paper-based resources, also recognizing their importance in this field.

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