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ESTUDIOS

Comparison of the effectiveness of ARASAAC pictograms and commercially available pictograms in children with autism spectrum disorder and complex communication needs

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Abstract: Communication skills can be severely affected in Level 3 autism spectrum disorder (ASD), also impacting social interactions and behavior, which presents a significant challenge for school-aged children. In these cases, the use of augmentative and alternative communication (AAC) is highly recommended. However, the wide variety of available AAC resources makes selecting the most suitable option difficult. This study compares two pictographic systems: ARASAAC pictograms and commercially available pictograms, aiming to analyze their impact on participants' progress. A quasi-experimental design was employed with 40 children with Level 3 ASD and complex communication needs: 21 used ARASAAC pictograms, while the remaining 19 used pictograms from Mi Estuche de Pictos ®. These pictograms were introduced through activities based on the aided augmented input strategy, pairing the speech therapist's natural oral input with corresponding visual representations. After 45 intervention sessions and three evaluation points using the Vineland-3 Scale, children who used ARASAAC pictograms showed significantly greater improvements in receptive and expressive communication, social skills, and behavior. Although the results with Mi Estuche de Pictos ® were also positive, ARASAAC stood out due to its iconicity, accessibility, and customization capabilities—factors that contributed to more positive progress in children with Level 3 ASD over time.
Keywords: Alternative/Augmentative Communication (AAC); Autism spectrum disorders; Complex communication needs; Pictographic resources; Speech therapy intervention.

ESP Comparación de la eficacia de los pictogramas de ARASAAC y pictogramas comerciales en niños con trastorno del espectro autista con necesidades complejas de comunicación

Resumen: Las habilidades comunicativas pueden estar gravemente afectadas en el trastorno del espectro autista (TEA) de Grado 3, impactando también en las interacciones sociales y el comportamiento, lo que supone un reto considerable para los niños en edad escolar. En estos casos, el uso de comunicación aumentativa y alternativa (CAA) es altamente recomendable, pero la amplia variedad de este tipo de recursos disponibles dificulta la selección de aquellos más adecuado. Este estudio compara dos sistemas pictográficos: los pictogramas de ARASAAC y los pictogramas comerciales, con el objetivo de analizar su impacto en la evolución de los participantes. Se empleó un diseño cuasiexperimental con 40 niños con TEA de Grado 3 con necesidades complejas de comunicación: 21 de ellos utilizaron pictogramas de ARASAAC y los 19 restantes usaron pictogramas de Mi Estuche de Pictos ®. Estos fueron introducidos mediante actividades basadas en la estrategia de estimulación asistida del lenguaje, asociando el input oral del logopeda con sus respectivas representaciones visuales. Tras 45 sesiones de intervención y tres momentos de evaluación con la Escala Vineland-3, los niños que utilizaron pictogramas de ARASAAC mostraron mejoras significativamente mayores en su comunicación receptiva y expresiva, en sus habilidades sociales y en su comportamiento. Pese a que los resultados con Mi Estuche de Pictos ® son también favorables, los resultados destacan el potencial de ARASAAC debido a su iconicidad, accesibilidad y capacidad de personalización, factores que contribuyeron a una evolución más positiva en los niños con TEA de Grado 3 a lo largo del tiempo.

Palabras clave: Comunicación Aumentativa/Alternativa (CAA); Trastorno del espectro autista; Necesidades complejas de comunicación Intervención; Recursos pictográficos; Intervención logopédica.

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Introduction

Communication is based on the transmission of signals through a shared code between a sender and a receiver. While the ability to communicate is innate in humans, its development relies on contact and interaction with others, particularly with parents and caregivers during childhood (Gómez & Strasser, 2021). However, when this process or social interactions are disrupted, significant difficulties may arise in various areas of development. This issue is particularly relevant in children with autism spectrum disorder (ASD), a neurodevelopmental condition that manifests in early childhood (Lai, 2022; Pan et al., 2021).

The Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition, Text Revision (DSM-5-TR) (APA, 2022), remains the most current and one of the primary references for the diagnosis of mental disorders. According to this manual, people with ASD exhibit significant deficits in social interaction and communication, along with a markedly restricted range of activities and interests (Rosen et al., 2021). DSM-5-TR classifies ASD as a neurodevelopmental disorder and introduce a three-level severity model. This model determines the level of support required based on the individual's specific characteristics: Level 3 ("Requiring very substantial support"), Level 2 ("Requiring substantial support"), and Level 1 ("Requiring support"). It is estimated that more than 70 million people worldwide have been diagnosed with ASD (Holyfield et al., 2017; WHO, 2023). Recent studies suggest that between 65 and 72 per 10.000 individuals in the global population have autism (Talantseva et al., 2023; Zeidan et al., 2022). In Spain alone, this condition affects approximately half a million people of all ages, with an estimated prevalence of 15 per 1.000 preschool-aged children and 10 per 1.000 school-aged children (Morales-Hidalgo et al., 2018; Vidriales-Fernández et al., 2023).

Around 30% of people with ASD, particularly those classified as Level 3, face complex communication challenges that limit their ability to express themselves verbally, through signs, or in writing (Gotham et al., 2009; Light & McNaughton, 2012). These difficulties often involve deficits in vocabulary expansion and the ability to respond appropriately in interactions with one or more conversational partners. Such challenges not only negatively impact social skills in everyday situations but may also influence behavior and have long-term effects throughout an individual's developmental stages (Torrens & Ruiz, 2021; Wang et al., 2023).

Visuospatial abilities observed in people with ASD (Cardillo et al., 2020; Di Mascio et al., 2019) have contributed to the implementation of augmentative and alternative communication (AAC) strategies when necessary. AAC encompasses all communication methods designed to assist users in expressing thoughts, needs, desires, and ideas. These tools can serve as either a complement or an alternative to verbal communication, whether to support temporary speech difficulties during recovery or to compensate for persistent communication disorders that hinder language development (Chazin et al., 2018; García et al., 2009).

The use of AAC systems is influenced by a complex interaction between exogenous and endogenous factors. Among the exogenous factors, key elements include the logical organization of pictograms, a distraction-free environment, and the active involvement of communication partners (Light et al., 2004; Schlosser & Sigafoos, 2002). Design features such as color, size, movement, and the novelty of stimuli also have a direct impact on the user's attention (Jagaroo & Wilkinson, 2008; Wilkinson & Light, 2014). On the other hand, endogenous factors—such as visual memory, sensory processing, and physiological arousal levels—play a critical role in determining how effectively the system is used. This highlights the importance of tailoring both the design and implementation of AAC systems to each user's individual characteristics, taking into account their sensory perception, physical access, and communication needs (Gómez-Taibo & García-Eligio de la Puente, 2018).

In AAC, signs establish a connection between a perceptible element and its mental representation. These signs can take various forms, such as icons, signals, cues, or graphic symbols, and are often accompanied by written words (Calleja Reina & Sotillo Méndez, 2023). However, the ability to interpret these signs is not innate. As a result, the degree of iconicity—that is, the extent to which a symbol resembles its referent—plays a critical role in facilitating the representation of both concrete and abstract concepts, thereby expanding communication opportunities for individuals with ASD (Pereira et al., 2020). The significance of this dimension lies in the fact that the higher the level of iconicity, the easier the symbols are to learn. This notion is encapsulated in what is known as the transparency hypothesis, as described by Cabello and Mazón (2018), which posits that more transparent or iconic symbols are acquired more quickly and with greater ease. In addition, AAC systems typically organize visual symbols within a structured space, such as physical panels with printed

pictograms or interactive screens in digital formats. This structured layout helps users access and locate symbols more efficiently, improving their interaction with the system (Jagaroo & Wilkinson, 2008).

Previous studies have shown that the use of pictograms facilitates communication in children with ASD, enhancing both symbol production and word comprehension when presented alongside spoken language (Acuña & Mendoza, 2020; Cáceres Acosta, 2017). However, there is still insufficient evidence regarding which pictogram sets are most effective for children with Level 3 ASD who have complex communication needs, particularly in Spanish-speaking contexts, especially concerning their most affected areas: communication, social interaction, and behavior (Sauer et al., 2021). Currently, there are multiple pictogram sets designed to support communication, each with distinct visual and structural characteristics. This diversity can create challenges in selecting the most suitable system for each user. In this regard, conducting comparative studies that assess the impact of different pictogram sets on user performance in participants with ASD is crucial, as it would help identify their advantages and limitations.

This study aims to compare the effectiveness of two different AAC resources—Aragonese Portal of Augmentative and Alternative Communication (ARASAAC) (Gobierno de Aragón, 2007) and Mi Estuche de Pictos ®—by analyzing their impact on children with ASD when presented in printed paper format. The central hypothesis is that pictograms with more iconic design features will result in better symbol comprehension and production.

To date, no study has directly compared these two pictogram sets in Spanish-speaking individuals diagnosed with Level 3 ASD, which underscores the relevance of this research. Cabello and Mazón (2018) provided evidence that ARASAAC symbols are perceived by students as having a higher degree of iconicity compared to symbols from other systems, such as Bliss or SPC. Building on this finding, the present study seeks to determine whether this perceived difference in iconicity is also reflected in clinical outcomes—specifically when comparing ARASAAC pictograms to those included in the commercially available pictograms. Although Mi Estuche de Pictos ® is a standardized set widely used in clinical practice due to its high level of iconicity, design differences between the two sets may suggest that ARASAAC symbols are more accessible for individuals with significant communication challenges.

Method

Participants

The study sample consisted of participants with ASD from Málaga, Spain, selected through purposive sampling. The sample initially included 55 potential participants, with 40 meeting the following inclusion criteria: (a) school-aged children (6–12 years old) selected for their diagnostic stability (De Pimentel, 2024; Fombonne et al., 2021), prevalence (Talantseva et al., 2023) and because this developmental stage is critical for acquiring fundamental social, communicative, and academic skills (Lima & Laplane, 2016); (b) Spanish as their primary language of instruction; (c) diagnosed with Level 3 ASD, as assessed by clinicians using DSM-5-TR criteria (APA, 2022); (d) complex communication needs, evidenced by limited functional communicative exchanges through verbal language (speech, signs, or writing); (e) the ability to focus on an activity for at least 10 minutes, according to teacher and caregiver reports; (f) unfamiliarity with the AAC resources used in the study, as verified through reports from the relevant speech therapists; (g) no visual or hearing impairments; and (h) signed informed consent from parents or the primary caregiver.

The equivalence between groups was ensured through the random assignment of participants, following CONSORT guidelines. This method guarantees a balanced distribution of baseline characteristics and minimizes bias when comparing the effects between groups. The final sample of 40 participants was assigned identification numbers and randomly divided into Group A and Group B using the Random.org software (Table 1). Both Group A and Group B underwent the same intervention strategy under identical conditions and timeframes, but with different pictogram sets

Table 1. Participant descriptions

	Group A	**Group B**
Participants	*n*=21	*n*=19
Gender	18 male 3 female	15 male 4 female
Age (mean and standard deviation)	7.29 (1.45)	7.21 (1.13)

Materials

Before the intervention, participants' baseline characteristics were evaluated using several standardized tools. Complex communication needs were measured through the Adaptive Behavior Composite (ABC) from Vineland-3 (Sparrow et al., 2016), which provides a broad overview of adaptive functioning in children with ASD. Intellectual abilities were assessed using the Test of Nonverbal Intelligence – Fourth Edition (TONI-4), suitable for individuals with verbal or motor impairments (Brown et al., 2019; Fopiano, 2021). Additionally, the Protocol for the Assessment of the Linguistic Communicative Profile of Individuals with Intellectual Disabilities and Complex Communication Needs (PCL-DIS-NCC) (Calleja Reina et al., 2021) was used to evaluate both language comprehension and expression across five subdomains: comprehension (PCL-EC), range of communication partners (PCL-EE-VI), communicative functions (PCL-EE-FC), modes of communication (PCL-EE-MC), and conversational topics (PCL-EE-T).

Regarding the materials used during the intervention sessions, Group A received targeted support using pictograms from ARASAAC. ARASAAC is an online resource developed by the Department of Education, Culture, and Sports of the regional government of Aragón, Spain. It provides a wide range of pictographic symbols and adapted materials under a Creative Commons (BY-NC-SA) license to support people with communication difficulties, helping them express their needs, desires, and thoughts effectively (Gobierno de Aragón, 2007). Designed for accessibility, ARASAAC is intended for use by both professionals and family members. It is available in multiple languages, including Spanish, English, Portuguese, French, German, and Italian, making it a widely accessible tool worldwide (Paolieri & Marful, 2018).

ARASAAC has an extensive collection of more than 30.000 pictograms and AAC resources with different graphic representations. These include symbols of food, leisure, places, objects, actions, emotions, education and concepts among other semantic areas, presented in five different options: color pictograms, black and white pictograms, photographs, sign language videos and descriptions with photographs containing how to sign a specific word (Rodrigo & Corral, 2013).

As highlighted by Cabello and Bertola (2015), ARASAAC pictograms exhibit a high degree of iconicity, meaning that the visual form of the symbol closely resembles its intended referent. This visual similarity makes the meaning of the pictogram more intuitively accessible, particularly for individuals who rely heavily on visual processing. Iconicity plays a crucial role in facilitating symbol recognition and learning, as it lowers the cognitive demands required to establish a connection between a symbol and its meaning. Cabello and Bertola's study found that ARASAAC symbols were consistently rated as both transparent and iconic—especially within concrete grammatical categories such as nouns and verbs. This high level of iconicity supports faster and more effective vocabulary acquisition, enabling users to infer symbol meanings without the need for explicit instruction. These qualities facilitate communication and understanding for people with ASD and other special needs (Cabello & Mazón, 2018).

ARASAAC offers highly customizable pictograms that can be adapted to individual needs by modifying icon features, background and frame color, verb tense, physical traits, grammatical indicators, and more. Text options also allow adjustments to font, size, placement, and capitalization (Méndez et al., 2018). A key strength of the platform is its inclusive design, aimed at promoting active participation of individuals with communication challenges in social and educational contexts. ARASAAC fosters collaboration by enabling users to share their customized materials, enriching its resource pool. Pictograms can be downloaded and printed for diverse applications, such as communication boards, games, calendars, and storybooks (Bertola, 2017). In recent years, ARASAAC has become one of the most widely used AAC platforms in Spain (Hervás et al., 2020).

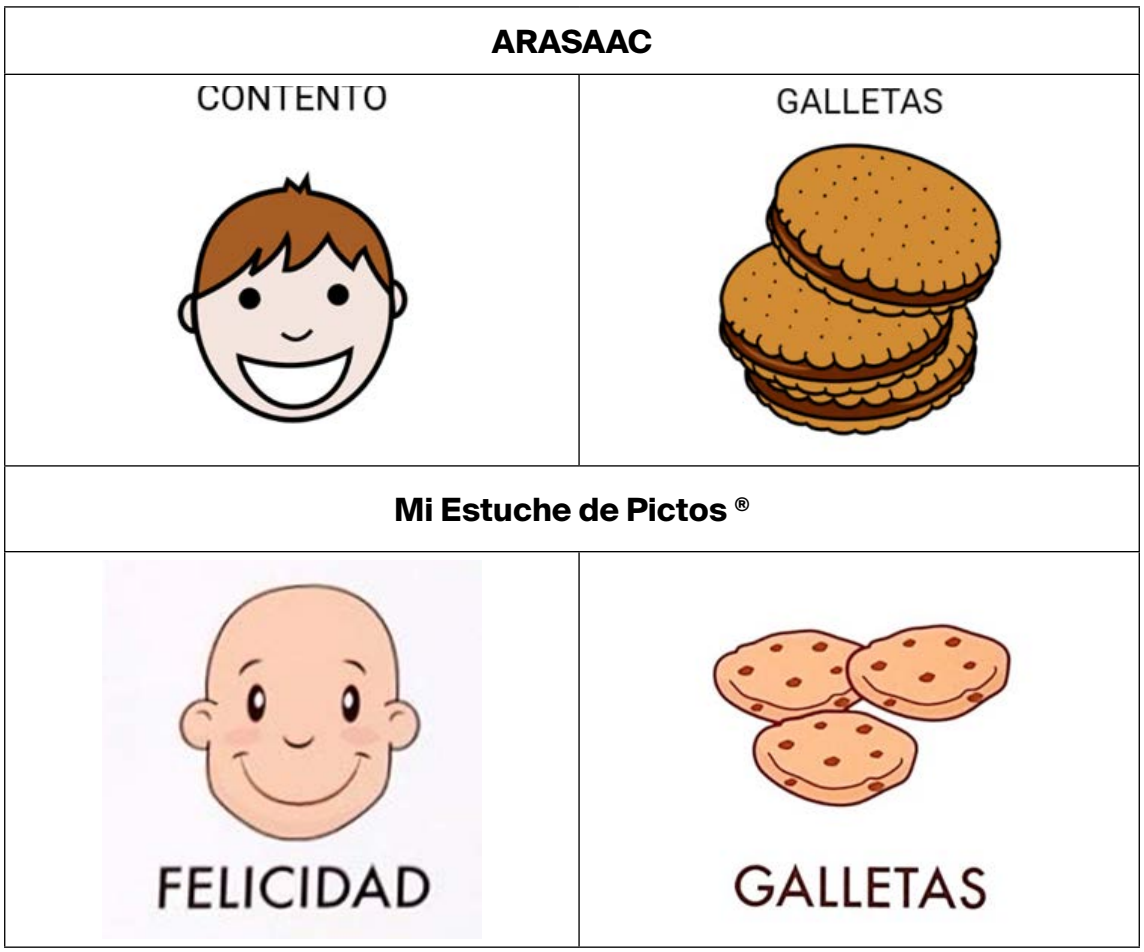
In addition to their visual clarity, ARASAAC pictograms have been normatively evaluated to provide standardized measures for their use in research and clinical settings. Paolieri and Marful (2018) collected normative data on 295 of the most commonly used ARASAAC symbols, providing indices such as name agreement, image agreement, visual complexity, conceptual familiarity, age of acquisition, and naming latency. Their results confirmed that the pictograms display high levels of image agreement and low visual complexity, which support faster and more accurate naming. These normative indicators make ARASAAC particularly valuable for designing interventions that require cognitively accessible and easily learnable materials.

The ARASAAC pictograms used in the study included visual aids for semantic fields (such as clothing, colors, food, vehicles, emotions, places, etc.), general vocabulary, and elements for creating social stories (Paolieri & Marful, 2018). All of those pictograms were well-defined, color images with a white background to ensure a high level of iconicity. The word was displayed in black uppercase letters at the top to complement the visual representation (Cabello & Bertola, 2015; Laher & Dada, 2023; Rayner, 1998).

For Group B, commercially available educational pictograms from Mi Estuche de Pictos ® were used. This practical tool, marketed by Editorial GEU, is designed to support and enhance alternative communication. It includes a collection of 535 pictograms in laminated card format, each measuring 7×7 cm. These cards are easy to handle and suitable for both individual and group use. They are recommended for children with ASD, communication difficulties, learning challenges, or those beginning literacy. This resource is currently available in Spanish, Catalan, and Italian for a standard price of €29.95 on the official Editorial GEU website. Additionally, a bilingual version is available, featuring educational pictograms with words in both Spanish and English.

They also have a white background, color images, and written words in black uppercase letters at the bottom. In this case, the pictograms are divided into 17 different categories: "Actions", "Activities/Therapy", "Food", "Animals", "Personal Hygiene", "Colors", "Basic Concepts", "Emotions", "Places", "Transportation", "Numbers", "Professions", "Body Parts", "Time", "Family", "Clothing & Accessories", and "Others" (e.g., "goodbye", "please"). The "Clothing & Accessories" category is only included in the Spanish version, which was used for this study.

The pictograms feature pre-designed illustrations that do not follow the same principles of iconicity and lack the structured design of ARASAAC pictograms (see an example in Figure 1).



Note: The original pictograms measure 7x7 cm and the photos were taken directly by the first author.

Figure 1. Pictograms examples used in the study

All materials are presented on paper, without any technological influence. In this case, the ARASAAC pictograms were printed on paper and laminated for enhanced durability, matching the size of those used in Group B (7×7 cm) to ensure consistency. The pictograms in both groups were adapted to meet the individual needs and preferences of each child, excluding items that were overly complex or inappropriate for their vocabulary or age.

Measures

The Spanish version of the Vineland-3 (Sparrow et al., 2016) was used to assess adaptive behavior in minimally verbal children with ASD (Pepperdine & McCrimmon, 2018), focusing on communication, daily living skills, and socialization. Scores are based on a Raw Score, which quantifies age-appropriate behaviors using three response options: 2 = Usually or Frequently, 1 = Sometimes, and 0 = Never. The Raw Score is then converted into a Scale-v Score using age-based normative tables (Domain-Level Form). None of the participants achieved the highest possible score in any of the evaluated areas. In this study, the Comprehensive Parent/Caregiver Form was completed by the independent observer (the independent speech therapist) instead of parents or teachers. This approach aimed to enhance data accuracy and minimize social desirability bias (Roselló et al., 2018). By relying on a professional with extensive firsthand interaction with participants, the study ensured that assessments were based on systematic and contextually relevant observations.

To meet the study's objectives, total Scale-v Scores were analyzed in the following domains:

- Communicative Range: Assessed receptive and expressive language through the subtests "Receptive" (39 questions on comprehension and following instructions), "Expressive" (49 questions on speech, emotions, vocabulary, and non-verbal communication), and "Writing" (38 questions on letter recognition, symbol understanding, and literacy-related skills).
- Social Range: Measured social abilities based on the total scores from the subtests "Interpersonal Relationships" (43 questions on recognizing people, engaging in interactions, making eye contact, and spontaneous responses), "Play and Leisure" (36 questions on interest in surroundings, toy interactions, and sharing behaviors) and "Coping Skills" (33 questions on adaptive behaviors like seeking comfort, asking for help, using polite expressions, managing emotions, and adjusting behavior).
- 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 evaluate disruptive behaviors

such as self-injury, environmental and material damage, and learning interference (Martínez-González & Gil, 2019). Higher scores in this domain indicate a greater presence of disruptive behaviors.

Measurement reliability was assessed using the internal consistency of the Vineland-3 Scale, with Cronbach's alpha as the primary indicator. Results showed satisfactory reliability across all age groups, with coefficients ranging from 0.74 to 0.87 for the Comprehensive Form and ABC, and from 0.80 to 0.87 for the Domain-Level Form and ABC. Test-retest reliability was evaluated using corrected correlations, following Pepperdine and McCrimmon (2018). Two administrations were conducted with the same respondent and examiner, 12 to 35 days apart. Corrected *r* values for adaptive domains and ABC ranged from 0.72 to 0.90, confirming the instrument's reliability for assessing targeted skills.

Procedure

Baseline measures

At baseline, participants underwent an assessment to gather information on their initial characteristics (Table 2). To evaluate complex communication needs, the ABC score from Vineland-3 was employed. This composite includes the Communication, Daily Living Skills, and Socialization domains, with percentile scores below 1% indicating severe functional limitations. Nonverbal intellectual abilities were measured using the TONI-4 test. No significant group differences were found on this measure ($t = .07$, $p > .05$), supporting the assumption of comparability at the start of the study. Language comprehension and expression were evaluated using the five subscales of the PCL-DIS-NCC protocol: PCL-EC ($t = -2.63$, $p > .05$), PCL-EE-VI ($t = -1.24$, $p > .05$), PCL-EE-FC ($t = 6.80$, $p < .05$), PCL-EE-MC ($t = -.59$, $p > .05$), and PCL-EE-T ($t = 5.19$, $p < .05$). Statistical comparisons showed no significant baseline differences between groups in most subdomains, except for communication functions and topics and preferences, suggesting initial differences in these specific communicative dimensions.

Table 2. Baseline characteristics of participants

	Group A	Group B
TONI-4 (mean IQ and standard deviation)	50.29 (5.44)	50.16 (5.38)
Vineland-3 (ABC)	Percentage = <1	Percentage = <1
PCL-DIS-NCC (mean and standard deviation)	• PCL-EC: 21.33 (1.01) • PCL-EE-VI: 18.52 (1.32) • PCL-EE-FC: 22.52 (1.43) • PCL-EE-MC: 20.43 (4.20) • PCL-EE-T: 19.81 (1.47)	• PCL-EC: 22.16 (.95) • PCL-EE-VI: 19.00 (1.05) • PCL-EE-FC: 20.26 (1.59) • PCL-EE-MC: 21.26 (4.71) • PCL-EE-T: 17.32 (1.56)

Note. IQ: Intelligence Quotient; ABC: Adaptative 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: Topics and Preferences. Compiled by the author.

Intervention

The study followed a quasi-experimental design with two independent groups over a 16-week period. Moment 1 included a pre-intervention assessment (baseline 1), followed by the AAC-based intervention from weeks 2 to 13. An intermediate evaluation was conducted in week 7 (Moment 2), and a final post-intervention assessment took place at week 16 (Moment 3), evaluating communication skills, social behavior, and general conduct to assess retention. All procedures complied with institutional and national ethical standards, including the Helsinki Declaration. Ethical approval was granted by the University of Málaga's Ethics Committee (CEUMA) (Ref: 19-2023-H), and participant confidentiality was strictly maintained.

All sessions were conducted in multidisciplinary centers, specifically in speech therapy offices, free of visual and auditory distractions. The communication contexts included playing with toys and other objects, social interaction with the communication partner, and quantifying problematic behaviors during the session. A consistent set of motivators (including toys, music, and other resources) as well as pictograms from both sets, were selected based on preference assessments, individual needs, and interviews with families and teachers conducted prior to the study. These materials were strategically arranged on the table to support the regulation of participants' impulses and to enhance the overall effectiveness of the intervention strategy (Holland et al., 2020; Martin & Wilkins, 2022).

Each week, a new item from the original set—previously unused—was introduced during the intervention periods (see the Appendix for additional details). Sessions were conducted individually, lasting 15 to 30 minutes, and took place 2 to 3 times per week, depending on participant availability and center scheduling. To prevent fatigue and frustration, strategic 5-minute breaks were incorporated after several activities. These breaks were not counted toward the total intervention time, ensuring that children remained focused and engaged throughout the sessions. The intervention followed a user-centered approach.

The first author attended most of the therapy sessions, accompanied by an independent observer who was a speech therapist to ensure inter-observer reliability. The independent observer was someone the participant recognized; however, since participants were from different locations, the assigned observer varied depending on the center. All therapy sessions were thoroughly documented through written notes, skills checklists, and video recordings. Written notes captured real-time observations, while checklists systematically tracked participants' progress. Video recordings allowed for detailed analysis and verification of the data.

The intervention employed combined with the AAC resources was aided augmented input, wich is a strategy that promotes both expressive communication and comprehension through visual stimuli provided by the speech therapist (Figure 2).

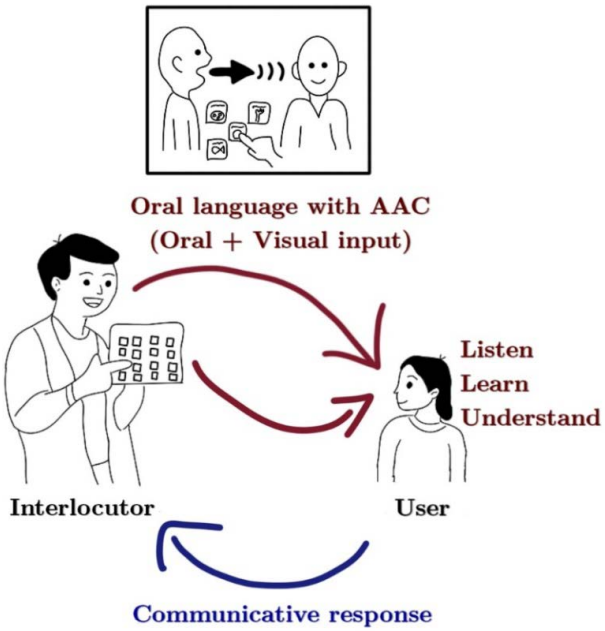


Figure 2. The aided augmented input process

This approach not only models language but also incorporates graphic symbols as an effective alternative communication method, integrating linguistic input into daily interactions, routines, and therapeutic instructions (O'Neill et al., 2018). For this strategy to be effective, the user's social environment must facilitate oral input, allowing linguistic experiences similar to those of individuals with typical development. By combining oral and visual channels, AAC is naturally modeled in conversations and structured activities, fostering communication, social, and educational opportunities that strengthen and expand the user's skills (Beck et al., 2009; Chazin et al., 2021; Muttiah et al., 2022).

The aided augmented input strategy was adapted from the research of Muttiah et al. (2022). These procedures involved natural social and communicative routines, such as toy play, engagement in various activities, and interaction with additional speech therapy tools and conversation partners. In each session, children were provided with at least twenty communication opportunities per activity. The speech therapist pointed to the pictographic symbols while implementing the aided augmented input strategy to help the children understand the images and their relation to real-world objects, thereby providing input, creating associations, and reinforcing correct responses (Logan et al., 2017).

The activities in both groups included environmental awareness, emotional recognition and imitation, exercises for semantic categories, object discrimination, association games, direct requests using pictograms ("I", "want..." with space to add the pictogram and the corresponding item), position games, exercises for classifying good and bad behavior, and basic literacy activities to differentiate sounds, letters, or words and associate written names with categories (Pereira et al., 2020). Sensory integration approaches were also incorporated, along with structured teaching using visual schedules, graphic organizers and simple visual aids, aiming to establish and reinforce connections while addressing potentially negative behaviors through shaping (López, 2015; Noda et al., 2022).

The pictograms were shown to participants one at a time, allowing them to associate each with the corresponding word or concept. The use of individual pictograms aimed to promote focused attention on a single symbol at a time, giving the participant sufficient time to process the meaning of each one before moving on to the next or adding others. The pictograms were selected based on the planned activities.

For storage, ARASAAC pictograms were kept in folders or boxes organized by semantic categories, allowing for quick and efficient access during the sessions. The pictograms from Mi Estuche de Pictos ® were stored in their own box with built-in dividers that separate the pictograms into 17 corresponding semantic fields, making them easier to locate. The box measures 9x8x9 cm. Additionally, for both groups, some pictograms were stored in envelopes or pockets, keeping them easily accessible as needed. This flexible yet structured organization helped maintain a smooth flow during the sessions, stimulating both oral and visual input without any disruptions.

Data analysis

The independent variable in the study was the use of aided augmented input with ARASAAC pictograms, compared to a strategy using commercially available educational pictograms. Dependent variables included scores from the Vineland-3 scale in the domains of communication, social skills, and disruptive behaviors, with performance ranging from 0% to 100% in 20% increments. Data were analyzed using SPSS ® Statistics 27.0, with Student's t-tests and repeated-measures ANOVA ($p < .05$) used to compare group performance. Interobserver agreement was recorded in 65% of baseline and 75% of training and maintenance sessions,

with average concordance of 90% during baseline and 94% during intervention. A speech therapist completed checklists after each session, which were cross-validated with formal assessment tools, confirming 90% procedural reliability. The author's consistent presence ensured fidelity throughout all phases.

Results

To assess the impact of the intervention strategy on communication, social, and behavioral areas, Vineland-3 scores were analyzed to determine how they varied based on the type of pictograms used. The scores of Group A (ARASAAC) and Group B (Commercially available pictograms) were compared across the three evaluation moments.

Communicative Range evaluation

First, performance on the Communicative Range was assessed, which encompasses various facets of communicative-linguistic development, including both expressive and receptive components. Statistically significant improvements were observed across all three evaluation moments: Moment 1 showed a mean difference of 12.07 ($t = 48.48$, $p < .05$), Moment 2 a difference of 16.20 ($t = 46.12$, $p < .05$) and Moment 3 of 19.90 ($t = 34.81$, $p < .05$). Between-group comparisons revealed no statistically significant differences at Moment 1 ($t = -.71$, $p > .05$), confirming baseline equivalence. At Moment 2, Group A already showed a significantly higher performance compared to Group B ($t = 5.06$, $p < .05$), and this difference increased further at Moment 3 ($t = 9.65$, $p < .05$), reflecting the greater impact of the combined intervention.

From the first to the third assessment, Group A showed a mean improvement of 10.86 points (SD = 2.46), compared to 4.48 points (SD = 1.19) in Group B. A repeated measures ANOVA confirmed the significant effect of the intervention: the combined use of ARASAAC and aided augmented input resulted in significantly greater gains compared to the use of other pictograms ($F_{(1.79)} = 270.35$, $p < .05$, $\eta^2 = .877$, $\beta\text{-}1 = 1$). Table 3 provides the full set of comparisons between moments and groups.

Table 3. Comparison of Communicative Range

		Group A			Group B		
		Moment 1	**Moment 2**	**Moment 3**	**Moment 1**	**Moment 2**	**Moment 3**
Mean		11.90	17.52	22.76	12.26	14.74	16.74
Standard deviation		1.75	2.20	2.46	1.36	.99	1.19
Standard error mean		.38	.48	.53	.31	.22	.27
95% Confidence Interval	Lower Limit	11.20	16.75	21.89	11.52	13.92	15.82
	Upper Limit	12.60	18.29	23.63	12.99	15.54	17.65
RS rec (mean and standard deviation)		46.62 (5.78)	54.10 (6.83)	62.24 (6.22)	49.05 (5.71)	52.47 (4.11)	56.00 (4.41)
RS exp (mean and standard deviation)		65.19 (9.40)	70.14 (8.42)	76.90 (7.04)	65.53 (7.21)	69.26 (6.10)	71.47 (6.05)
RS wrn (mean and standard deviation)		7.24 (5.29)	8.81 (6.49)	10.62 (6.68)	4.79 (4.49)	7.32 (4.37)	8.26 (4.33)

Note. RS rec: Raw Score Receptive; RS exp: Raw Score Expressive; RS wrn: Raw Score Written.

Social Range evaluation

An additional analysis was conducted to assess the Social Range based on the type of pictograms used. Social Range scores reflected participants' social skills across various domains, including interactions with conversation partners, the ability to establish emotional connections, and behavior in social contexts. Statistically significant differences were found between the measures of the developmental test. Moment 1 showed a mean difference of 14.72 ($t = 43.35$, $p < .05$), Moment 2 of 20.05 ($t = 40.73$, $p < .05$) and Moment 3 of 24.15 ($t = 31.88$, $p < .05$). No significant differences were observed between the groups at Moment 1 ($t = .40$, $p > .05$), indicating that both groups were comparable at baseline. By Moment 2, Group A exhibited significantly better outcomes than Group B ($t = 5.28$, $p < .05$), with this performance gap widening even further at Moment 3 ($t = 9.74$, $p < .05$), suggesting a stronger effect of the combined intervention.

In a second stage, the mean differences of Group A and B were analyzed. The results showed an improvement in the mean Social Range of Group A of 13.09 points (SD = 3.26) versus 5.37 points (SD = 1.54) in Group B. Table 4 shows the differences between the first and last assessments in participants. A repeated ANOVA analysis was performed. The results show that there are significant differences in the Social Range when comparing the results of the combined intervention of ARASAAC and aided augmented input with the intervention with other pictograms after 16 weeks of training ($F_{(1.82)} = 194.50$, $p < .05$, $\eta^2 = .837$, $\beta\text{-}1 = 1$).

Table 4. Comparison of Social Range

		Group A			Group B		
		Moment 1	**Moment 2**	**Moment 3**	**Moment 1**	**Moment 2**	**Moment 3**
Mean		14.86	21.95	27.95	14.58	17.95	19.95
Standard deviation		2.33	2.78	3.26	1.98	1.87	1.54
Standard error mean		.50	.60	.71	.45	.42	.35
95% Confidence Interval	Lower Limit	13.89	20.89	26.80	13.57	16.83	18.74
	Upper Limit	15.81	23.01	29.09	15.58	19.05	21.15
RS ipr (mean and standard deviation)		36.81 (8.01)	42.95 (8.36)	54.38 (8.95)	35.42 (7.71)	43.42 (7.94)	49.21 (7.59)
RS pla (mean and standard deviation)		21.57 (6.85)	32.29 (7.66)	41.57 (7.69)	20.47 (7.11)	26.37 (8.51)	29.42 (6.89)
RS cop (mean and standard deviation)		1.71 (.90)	9.38 (5.13)	16.52 (9.29)	1.74 (1.04)	3.26 (3.01)	4.53 (2.89)

Note. RS ipr: Raw Score Interpersonal Relationships; RS pla: Raw Score Play and Leisure; RS cop: Raw Score Coping Skills.

Behavioral Range evaluation

Finally, the same procedure was followed to determine the evolution of the Behavioral Range in participants, focusing on identifying and quantifying problematic behaviors that may hinder the development of other skills. Significant differences were found between the developmental test measures at the three measurement moments. Moment 1 showed a mean difference of 29.47 ($t = 76.10$, $p < .05$), Moment 2 of 23.37 ($t = 36.51$, $p < .05$) and Moment 3 of 16.85 ($t = 24.81$, $p < .05$). Likewise, at Moment 1, the analysis revealed no statistically significant differences between the groups ($t = -1.16$, $p > .05$), supporting baseline comparability. However, by Moment 2, Group A had significantly outperformed Group B ($t = -4.05$, $p < .05$), and this disparity became even more pronounced at Moment 3 ($t = -7.07$, $p < .05$), underscoring the enhanced effectiveness of the combined intervention.

Next, the mean differences between Group A and B were analyzed. The results showed an improvement in the mean Behavioral Range of Group A of 15.24 points (SD = 3.45) compared to the improvement of 9.74 points (SD = 1.98) in Group B. Table 5 shows the differences between the first and last assessment in participants. A repeated ANOVA analysis was performed. The results showed that the combined intervention of ARASAAC and aided augmented input significantly decreased disruptive behaviors compared to the intervention with the other pictogram set after a 16-week training ($F_{(2.00)} = 270.23$, $p < .05$, $\eta^2 = .877$, $\beta\text{-}1 = 1$).

Table 5. Comparison of Behavioral Range

		Group A			Group B		
		Moment 1	**Moment 2**	**Moment 3**	**Moment 1**	**Moment 2**	**Moment 3**
Mean		29.05	21.29	13.81	29.95	25.68	20.21
Standard deviation		2.24	4.00	3.45	2.63	2.64	1.98
Standard error mean		.49	.87	.75	.60	.60	.45
95% Confidence Interval	Lower Limit	27.97	19.77	12.54	28.81	24.09	18.88
	Upper Limit	30.12	22.80	15.07	31.08	27.27	21.53
Section A (mean and standard deviation)		8.57 (1.85)	6.81 (1.80)	4.57 (1.93)	9.05 (1.26)	7.74 (1.32)	6.05 (1.64)
Section B (mean and standard deviation)		7.43 (1.50)	5.95 (1.83)	4.00 (1.64)	8.05 (.91)	7.37 (1.11)	6.05 (1.43)
Section C (mean and standard deviation)		13.05 (1.46)	8.52 (2.31)	5.24 (2.50)	12.89 (1.76)	10.58 (1.86)	8.26 (1.66)

Discussion

This study aimed to examine the effects of two different pictogram systems—ARASAAC and commercially available printed pictograms—to determine which option yields better outcomes for children diagnosed with Level 3 ASD and complex communication needs. Both approaches have been shown to reduce deficits in socio-emotional reciprocity while enhancing participants' interests, shared affect, play skills, and responsiveness to simple social interactions. Individually tailored visual stimuli can be engaging, detailed, and accessible, improving focus and minimizing distractions (Bellini et al., 2007; Landa, 2018). Throughout the intervention, aided augmented input was consistently applied, integrating visual and auditory input to create a

richer and more engaging communication experience (González-Mercado et al., 2016), making this strategy a valuable complement to the AAC resources used.

The population with ASD is highly heterogeneous, resulting in a wide variety of communicative, cognitive, functional, and sensory profiles within the spectrum (Mottron & Bzdok, 2020). This diversity was reflected in the study's results, where significant differences were observed between Groups A and B from the initial measurement. By Moment 3, participants with ASD in Group A showed a substantial increase compared to Group B in both Communicative and Social Range. These gains contribute to enhancing each child's ability to learn and develop new skills (Jacob et al., 2022).

Participants in Group A showed an increase in scores related to communication skills, leading to more frequent use of gestures, pointing to the referenced object, adhering to conversational rules and turns, and sharing attention more often. The association between the real object and its corresponding pictogram was also accurate. Given the scores obtained, this suggests that ARASAAC pictograms, as described in the study, are more suitable for the participants than the commercially available pictograms used for comparison. However, they still exhibit semantic-pragmatic challenges and difficulties in using oral language (Friedman & Sterling, 2019). These challenges decrease as expressive skills improves, with receptive skills showing a more significant progression. Additionally, there was an increase in the ability to develop, maintain, and understand social interactions. Participants were more likely to adjust their behavior, share activities, and show interest in other people and elements of their environment represented by the pictograms.

On the other hand, the Behavioral Range showed an inverse trend. AAC resources enhanced the intervention sessions, making them more rewarding and satisfying for both the user and the speech therapist. They also helped minimize challenging behaviors and negative situations, fostering a more stable and manageable working environment. This result can be attributed to the participants' increased engagement in activities and the iconicity of the materials, which were tailored to their needs. This captured their attention, boosted motivation, and facilitated anticipation through twenty communication opportunities per activity, repeated over the 16-week study. The gradual increase in the number of pictograms ensured that the process remained manageable and not overwhelming or overly challenging (Castillo Roch & Grau Rubio, 2016; Muttiah et al., 2022). Nevertheless, in the third evaluation moment, Group A demonstrated a significant reduction in problematic behaviors observed during the intervention sessions. The combined strategy with ARASAAC pictograms had a stronger impact in this area compared to strategies using other commercial pictograms.

Throughout the intervention, aided augmented input was systematically employed, combining visual and auditory cues to enrich the communication environment—making this approach a valuable complement to the AAC resources utilized.. This approach allowed for better retention of information when presented both visually and auditorily, benefiting participants with ASD due to their visuospatial strengths (Gillespie-Smith & Fletcher-Watson, 2014; Pereira et al., 2020). The findings suggest that using this combined strategy with ARASAAC in children with Level 3 ASD significantly enhances the evaluated areas within a controlled speech therapy setting. These conclusions extend the work of Cabello and Mazón (2018), who also highlighted the high iconicity and ease of learning associated with ARASAAC pictograms in children with developmental language delay, specific language impairment, and ASD. While both studies support the superior transparency and learnability of ARASAAC symbols, the present results provide further evidence that these pictograms can facilitate broader communicative, social, and behavioral gains when used in conjunction with the aided augmented input strategy. Additionally, the long-term improvements observed in our participants reinforce Cabello and Mazón's conclusion that higher iconicity enhances not only initial symbol acquisition but also the speed and durability of learning, consistent with the transparency hypothesis.

Despite this, Mi Estuche de Pictos ® maintains a high level of iconicity, and the number of pictograms it includes is appropriate for the study population and its characteristics. This makes it a valuable AAC resource that could be effectively integrated into intervention sessions, primarily serving as a complementary tool alongside other supports.

In summary, the results in the communicative, social, and behavioral areas showed a positive and encouraging trend in both groups. However, Group A benefited more significantly from the ARASAAC pictograms compared to Group B. These pictograms facilitated visual comprehension and vocabulary representation through a structured and visually accessible system, combined with aided augmented input. This strategy allowed participants to access rich, detailed, and organized input, promoting communication and understanding (Biggs et al., 2018; Dada & Alant, 2009). Moreover, the strategy, along with the pictograms, provided a predictive and consistent environment that supported learning and interaction in various situations of interaction with the interlocutor (Remner et al., 2016; Tato, 2021).

The differences observed between both groups could also be attributed to ARASAAC's high level of customization. The pictograms from the other resource are pre-designed, with one of their main advantages being the large number available, which align well with various activities and interactions between the speech therapist and the child. However, ARASAAC offers an even greater selection of pictograms and vocabulary, making it highly unlikely to encounter situations where a needed pictogram is missing. Additionally, ARASAAC's customization features allow for modifications within the pictograms themselves. While most vocabulary items were used in their default settings, pictograms representing people were often adjusted. Specifically, when referring to the user or a familiar person, physical traits such as skin tone, hair color, and gender could be personalized, making the representations more accurate and relatable. These customizable features contrast with the more standardized presentation used in Cabello and Mazón (2018). While their study confirmed that ARASAAC pictograms were more iconic and easier to learn than other symbol sets like SPC and Bliss, our findings suggest that the ability to personalize visual supports may play an important role

in strengthening the association between the pictogram and its referent, thereby enhancing user engagement and learning outcomes.

The placement of written text within pictograms may also have influenced the results. Mi Estuche de Pictos ® displays words in a fixed format at the bottom of the pictograms. For example, within the semantic field of emotions, a pictogram depicting a smiling child is labeled as "FELICIDAD" (in English, "HAPPINESS"). While this is a valid term, other words might be more appropriate in natural or therapeutic contexts, such as "CONTENTO" (in English, "HAPPY"). ARASAAC allows speech therapists to customize these labels, selecting the most contextually relevant word for each case. Moreover, ARASAAC places text in uppercase letters at the top of the pictograms, a design choice that may facilitate visual processing. Research suggests that visual perception follows a top-down approach, where individuals first scan the upper part of an image before moving downward. This aligns with eye-tracking and reading behavior studies, which indicate that people tend to focus on the upper regions of visual stimuli first, influencing how information is perceived and processed (Clifton et al., 2016; Hyönä, 2010). By positioning text at the top, ARASAAC may enhance readability and comprehension, particularly for people with language difficulties who benefit from structured visual cues.

This study offers several practical implications. First, the findings highlight the importance of interventions focused on communicative, social, and behavioral skills in children with Level 3 ASD. The differences between the first and final assessments in Group A suggest a more favorable progression. Therefore, the intervention using aided augmented input with ARASAAC pictograms proves effective and could be implemented in various contexts. Second, the study outlines a procedure for conducting interventions with severely affected children with ASD, emphasizing the joint presentation of oral and visual input as essential for understanding reality. Children with ASD can greatly benefit from visual supports (Noda et al., 2022), with ARASAAC standing out as particularly valuable due to its unique customization features.

Limitations

This research presents some limitations. First, the inclusion criteria, which aimed to maintain some homogeneity in the groups, limited the sample size. However, similar studies have used comparable sample sizes (e.g., Muttiah et al., 2022) and may still meet the assumptions of the statistical tests used. Second, using the speech therapy office as the primary setting and adapting it to the aided augmented input strategy may create complex and somewhat unnatural situations. To prevent this, it's crucial to consider each participant's preferences, vocabulary, and characteristics, which is why the scenarios in this study were highly controlled. Additionally, paper-based materials are more prone to damage or loss, which highlights the importance of laminating them for durability and having backup copies available when needed.

One of the most significant limitations encountered during the intervention was related to the AAC materials themselves. For aided augmented input to be implemented effectively—naturally complementing oral input with the corresponding visual representations—each session requires thorough preparation to ensure that all necessary pictograms are available during activities, games, or social and behavioral skill-building situations. This means that the vocabulary and semantic fields to be targeted must be carefully planned in advance, leaving only a small margin for spontaneous interactions. At times, the process may be slower or briefly interrupted when searching for a pictogram and placing it on the table, making the interaction less fluid. This opens the door for future research to explore faster and more efficient alternatives.

Conclusions

Both AAC resources have proven to be beneficial; however, in comparison, ARASAAC has emerged as a promising tool for enhancing skills in children with Level 3 ASD and whit complex communication needs. Its unique characteristics and high iconicity provide effective alternative communication methods while improving comprehension and interaction abilities. However, further research is needed to fully understand the long-term effects and potential variations of the aided augmented input strategy, including the use of other pictogram sets. Such research efforts would provide a more nuanced understanding of the intervention's effectiveness, enabling the development of personalized, evidence-based interventions for users with ASD. This would better prepare professionals and families to work on receptive and expressive communication, as well as social and behavioral skills, by selecting appropriate AAC pictograms or resources alongside the proposed intervention strategy.

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Conflict of interests

Los autores declaran no tener ningún conflicto de intereses en relación con la investigación, la autoría o la publicación de este artículo.

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Ana Paula Couceiro Figueira: Conceptualización; Recursos; Supervisión; Validación; Visualización.
Marina Calleja Reina: Conceptualización; Adquisición de fondos; Administración del proyecto; Recursos; Supervisión; Validación; Visualización.

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Appendix. List of pictograms used in the intervention

	Category	Pictograms
Original set example	Basic Concepts	Yo, más, terminar, sí, no, bien, mal
	Food	Agua, galletas, zumo, pan, pizza, hamburguesa, macarrones, tomate
	Emotions	Contento/Felicidad, triste/tristeza, enfadado/ira
	Colors	Rojo, verde, azul
	Places	Casa, colegio/aula, baño, silla, mesa
	Personal Hygiene	Lavarse las manos, cepillo de dientes, peinarse
	Actions	Jugar, sentarse, mirar, coger, comer, beber
	People	Mamá, papá, hermano/hermana, abuelo/abuela
	Clothing	Camiseta, pantalón, zapatos
	Body Parts	Cabeza, mano, pies
	Animals	Perro, gato, pájaro, pez
	Transportation	Coche, barco, avión
	Toys	Pelota, bloques, lápices
	Others	Por favor, gracias, hola, adiós
Weekly additions example	Basic Concepts	Arriba, abajo, dentro, fuera, gustar, abrir, cerrar
	Food	Manzana, pera, leche, yogurt, queso, jamón, limón, huevo, pollo
	Emotions	Asustado/miedo, amor, dolor, cansado
	Colors	Amarillo, naranja, rosa, blanco, negro
	Places	Calle, cocina, salón, dormitorio/cuarto, parque
	Actions	Silencio, dibujar, encender, apagar, esperar/stop, querer, andar
	People	Maestro/profe, maestra/seño, logopeda
	Clothing	Calcetines, gafas, gorra, chaqueta, paraguas
	Body Parts	Boca, lengua, ojos
	Animals	Vaca, mariposa, pato, conejo
	Transportation	Moto, tren, bicicleta, autobús
	Toys	Puzle, peluche, música, juegos

Note: The examples are presented in Spanish, as this was the language used in the context of the study.