Technologies in the education of children and teenagers with autism: evaluation and classification of apps by work areas

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Abstract

Mobile apps represent a resource with great potential for encouraging the development of many skills, given the high number of apps available and the quick access to them. Many professionals and families include these resources in the education and therapy of children with autism. For a group with such particular needs, a review of the apps is great importance, since, due to their characteristics, the apps must provide content, design and pedagogical aspects that fit those needs. Through a previously validated system of indicators, 155 free apps on Google Play were evaluated, using "autism" in English and in Spanish. We determined which work area each app developed, as well as which were the most multifaceted. Having evaluated the recorded data, we calculated frequencies, percentages and reliability, as well as parametric contrast and correlation statistics. We found that the focus of most apps was on executive functions, language and entertainment, with a minority devoted to the emotional sphere or time management. However, 98.06% of the apps worked on several areas, which makes them more functional but with the downside of not being specialized. Most apps were placed in the "recommendable" level but with margin for improvement in increasing their functionality.

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1 Introduction

Autistic Spectrum Disorder (ASD) is characterized by the presence of impairments and difficulties in areas connected to communication and social interaction, along with restrictive patterns with respect to diversity of behaviours and interests (APA, 2014). Autism is a part of ASD, according to the APA manual. Wing (1998) defines it as a set of symptoms associated with three dimensions (autistic triad): impairments and delay in language and communication, both verbal and non-verbal; impairments in the social sphere, more specifically in interpersonal reciprocity; and impairments in behaviour and thinking.

The global prevalence of people with autism has been measured by various authors and for various contexts, but the figures are not exact. Fortea et al. (2013) show that it could affect 60–70 of every 10.000 people; APA (2014) and March et al. (2018) state that it could comprise 1% of the population; Anzaldo and Cruz Ruiz (2019) assert that it affects one out of every 160 children in the world; and Málaga et al. (2019) show that in countries such as the United States it comprises one of every 59 children, and in Portugal, one of every 806. Even with this lack of agreement, the prevalence is notable. It is therefore important that these children are offered the care and education to enable their comprehensive and autonomous development from an early age. It is vital for professionals and specialists who participate in their education and/or psychopedagogical interventions to have the requisite training and means, including digital techonologies and material specifically designed for this group.

With this in mind, having searched through the different areas in which children and adolescents with this disorder have greater vulnerability – communication, language, emotions, basic instrumental skills, executive functions and time management – we observed that information and communications technology (ICT) in all its varieties (smartphone, tablet, communication boards, computers, etc.) achieves positive results in their enhancement and development. "Pupils with ASD often require the intervention of a wide range of services adapted to their specific needs" (Cappe et al., 2017, p. 498). Various studies (Castro & Mallón, 2019; David et al., 2019; González et al., 2016; Guzmán et al., 2017; Hernández & Sosa, 2018; Lorenzo et al., 2021; Pinel et al., 2018; Silva & de Rodríguez, 2018; Terrazas et al., 2016; Tsikinas & Xinogalos, 2020; Vlachou & Drigas, 2017; Wang & Xing, 2021) show the benefits that ICT offers this community, with a wealth of content focused on the comprehensive and specialized development of people with autism.

1.1 Apps for children with ASD and autism

In particular, apps provide a resource with great potential for working on and encouraging the development of many skills, given the high number of apps available and the quick and simple access to them (Gallardo-Montes et al., 2021a). Similarly, studies focused on children with autism using smartphone and tablet

Table 1 Studies focused on the use of apps with children with Autism Spectrum Disorder

Work	Purpose/Objective	App/Operating System	Results
Jiménez et al. (2017)	To analyse the influence of apps in the development of language and communication in a child with ASD.	CPA, LetMeTalk, Niki Talk, PictoDroid Lite … (Android/iOS)	Progress in the prerequisites of language, communicative intent and behaviour.
Fage et al. (2018)	To promote the school inclusion of 30 children with ASD through assistive apps based on cognitive and care rehabilitation.	Package of School apps + (iOS)	Improvements in socioadaptive behaviours and social response in the school environment.
Sung (2018)	To examine the effects of the use of apps addressing social skills in 3 children with autism.	Cuedin-Autism Early Intervention App, Autism Help y SocialSkills for Autism KLoog2 (Android)	Substantial improvements in social skills.
Bondioli et al. (2018)	To alleviate the sensory tensions that children with autism have when faced with a visit to the dentist and oral care.	MyDentist (Android)	Reduction of stress and anxiety in dentist visits.
Teixeira and Cunha (2019)	To teach early mathematical skills to 8 children with autism.	123 Autism (Android)	Learning of mathematical skills and increase in attention, concentration, behaviour and motivation.
Sweidan et al. (2019)	Learning of concepts linked to language, mathematics and social skills.	Autistic Innovative Assistant (AIA) (Android)	Progress in basic linguistic, mathematical and social concepts.
Lázaro-Cantabrana et al. (2019)	To test the usefulness of a safety app for people with ASD, corroborated with 18 families.	SOS TEA (Android)	Improvements in the understanding of information and capacity for expression and communication.
Smith et al. (2020)	Intervention through social stories in digital format with 22 children with autism.	SOFA (Android)	Greater comprehension of social stories and decrease in anxiety.
Aguilar-Velázquez et al. (2020)	To work on reading and writing with 10 children with autism.	LEA: Lecto-Escritura para Autismo (Android)	Stimulation of learning acquisition of cognitive, perceptual and motor skills, through a controlled, supervised and structured use.
Vyshedskiy et al. (2020)	Language development in 6454 children with ASD.	Cognitive and Language Therapy with MITA (Android)	Improvements in perceptive and expressive language.

apps have been increasing, and many authors have described their experience and success in using them (Table 1).

As well as being a good option for entertainment for any section of society, apps have potential beyond mere recreation for children with autism. Their content, and the way it is laid out, is presented in a controlled way, without ups and downs or intimidating situations, which is favourable for children and adolescents with autism (González et al., 2016; Hernández & Sosa, 2018; Terrazas et al., 2016). The digital-format tasks are also attractive to the user (Lozano et al., 2013b; Suárez et al., 2015), offering visual stimuli that are highly appealing to children with autism (García et al., 2016; Hernández & Sosa, 2018; Jiménez et al., 2017). In addition, authors such as García et al. (2016) and Jiménez et al. (2017) uphold the idea that interventions supported by apps facilitate and stimulate language and communication.

1.2 Previous studies on the evaluation of apps

Studies that examine apps for children and adolescents with functional diversity are numerous and varied. Cayton et al. (2015) assessed mathematics apps on the Apple App Store with regard to mathematical content, feedback, user interaction and adaptability. Crescenzi and Grané (2016) carried out a content analysis of 100 apps for children between the ages of six months and eight years old, examining their visual and interactive design, and they concluded that the quality of the aspects they measured was low. Larco et al. (2018) assess the quality of 73 apps on Google Play for people with disabilities, concluding that improvements were needed regarding personalization and interactivity. Kucirkova (2019) studied the design parameters of apps for creating children's stories. Crescenzi et al. (2019), in a systematic review of 200 apps for eight-year-old children, related to the safety and risks involved from an ethical perspective, underline the need to consider several aspects, including: mechanisms for protection; tools to change settings; stereotypes; knowledge held prior to using the app; and the verbal component presented. Leech et al. (2021) study mental health-focused apps for adolescents and young adults and the benefits following their use.

However, there are few studies that focus on the evaluation of apps for people with autism (Table 2). We need to pay attention to the particular areas in which people with this condition have greater difficulty, in order to find those apps that include suitable content based on their needs.

1.3 Spheres or areas in which children and adolescents with autism present greater difficulty

Children with autism exhibit significant impairments in the area of communication, along with many difficulties in language processing (Orellana, 2016; De Castro et al., 2018). As a consequence, there is impaired social interaction. ICT offers resources and tools that promote precisely the communication competence (Peirats et al., 2019). The software that supports language and communication makes it possible to create material that is connected to the communicative process through

Table 2 Studies focused on the evaluation of apps for children with Autism Spectrum Disorder

Work	Purpose/Objective	Conclusions
Sofian et al. (2016)	To identify the existing usability factors that have been used up until now to design the interface of an app for children with autism.	Particular attention is given to efficacy, efficiency, satisfaction, ease of use, appearance and understandable design.
Dattolo and Luccio (2017)	To analyse guidelines for the development of apps accessible to people with ASD.	Not all apps are accessible nor adapted to the characteristics of people with ASD. The language, sounds and narrations could be improved.
Boster and McCarthy (2018)	To investigate the format of apps addressing augmentative and alternative communication.	The importance of a design and format is maintained by speech therapists and families, adapted to the needs of the child with ASD.
Crespo and Martín (2018)	Review of articles focused on iOS and Android apps for children with autism.	The apps focused on behaviour, communication and learning are ideal and numerous for children with autism. However, a greater number of apps for families is needed. Apps for leisure and entertainment for this group are scarce.
Sofian et al. (2018)	Systematic review to study the usability factors used for the design of apps for children with autism.	They find that comprehension and appearance are included as usability factors due to their relation with the characteristics of children with autism.
Adamu et al. (2019)	To study the iOS and Android apps for children with autism developed to provide an environment for learning and communication.	The apps have interfaces adapted to the child's characteristics, which facilitate their concentration in carrying out the tasks given. The apps have improved with the advance of technology, with noticeable improvements in their usefulness.
Xanthopoulou et al. (2019)	To analyse the iOS and Android apps for children with ASD to give an overview of their characteristics and the developmental area they work on.	There is no guidance for the selection and use of the apps, and so families and professionals are advised to supervise the apps before giving them to children.
Sanromà-Giménez et al. (2021)	To design an instrument for the assessment of apps for people with autism.	Instrument focused on discovering the technical and descriptive characteristics of an app for people with autism, as well as their pedagogical aspects, inclusivity and educational accessability.

Table 2 (continued)

Work	Purpose/Objective	Conclusions
Gallardo-Montes et al. (2021b)	Evaluation of 88 apps available on Android focused on basic instrumental skills (oral language, reading, writing and mathematics) for children with autism.	Most of the apps focused on aspects linked to oral language (81.82%) and reading (87.5%), but few were aimed at writing (44.32%) and mathematics (23.86%). For oral language, the sub-area that was least present in the apps was syllables (3.4%); in reading it was reading fluency (5.2%); in writing, teaching spelling (5.13%); and in mathematics, multiplication and division (9.52%).
Gallardo-Montes et al. (2021a)	Assessment of the quality of 155 apps available for Android for people with autism.	The assessment established a ranking of the apps according to the quality of their design, content and pedagogical aspects. Only 14 apps obtain scores notably higher than the rest. These apps best fit the needs of people with autism.
Hanna et al. (2021)	To evaluate apps available on iTunes and Google Play aimed at teaching social skills to people with ASD, giving particular attention to the behaviour change procedures they incorporate.	The quality of the apps and the amount of behaviour change procedures vary between developers. The content that they aim to address should be presented clearly to give good guidance to families and professionals.
Haque et al. (2021)	Assessment of the *mCARE* app available for iOS and Android focused on the remote monitoring of children with ASD.	The Value Sensitive Design (VSD) produces an app that is easier to use in accordance with the socio-economic and cultural values of families.
Hussain et al. (2021)	Systematic review to investigate iOS apps for children with autism and how teachers can use them with these children.	The apps are effective at helping children to acquire linguistic and communicative skills due to their flexibility and portability. A systematic review method is recommended in the use of mobile devices.
Lian and Sunar (2021)	Systematic review to examine mobile augmented reality apps for people with ASD.	The quality of the augmented reality and the design focused on the characteristics of people with ASD need to be improved.

images, personal photographs and pictographs, enabling the user to create personalized schedules and social histories (Hernández & Sosa, 2018). Thus it can be adjusted to the interests of the child, young person or adult with ASD, which is essential for motivating communicative interaction (Baixauli et al., 2017).

Regarding the emotional sphere, children and young people with autism have a diminished capacity for understanding mental representations (Pedreño et al., 2017). An example of this is their difficulty in comprehending emotions, beliefs and intentions (Mazza et al., 2017). Authors such as Lozano and Merino (2015) state that, through a structured and well planned intervention, it is possible to improve the emotional competences. Successful studies and experiences, such as those of Lozano et al. (2013a), González et al. (2016) and Matey (2017), show improvements in understanding emotions with the aid of technological resources and apps in children with autism. Thus, the appropriate and organized use of these types of resources can guide psychopedagogical interventions toward positive results.

Pouw et al. (2013) add that children and adolescents with autism present an impaired capacity to create a Theory of Mind (ToM), which is closely connected with social interaction. This theory addresses the ability of people to attribute mental states to oneself and to others, through which they can understand their own and others' behaviour (Premack & Woodruff, 1978). ToM produces patterns or behaviours that enable a person's communicative and social development with their surrounding environment. Because processes integral to human development operate in ToM, an effort is made to promote them in people with autism from an early age. Some of the areas that converge in ToM are communication, language and the emotional sphere – the areas in which people with autism have most difficulty.

In terms of the basic instrumental skills, Íñiguez (2013) states that "instrumental learning is based on the acquisition of essential instruments and tools that are the basis for accessing the rest of knowledge and attaining an education of quality" (p. 1). People with autism display difficulties in learning these types of competence, such as artihmetic, writing and reading. Detecting these obstacles and treating them are two key aspects in intervening with children with autism.

"Learning to read and write is perhaps the first truly academic action in schools; it marks a before and after in the life of a child. Knowing how to read and write is, nowadays, something we expect of any person" (Autismo Diario, 2017, p. 1). The learning of reading and writing represents a step forward in development, since it gives an improved under-standing of language and its development. Pérez et al. (2012) stress that "teaching to read in autism does not only mean one step further in the natural process of education and culturalization. In autism, reading and writing can provide a way in for intervention on particularly affected aspects" (p. 85). In this regard, apps offer a large range of material to work on these concepts in a playful and active way.

In addition, people with autism exhibit difficulties in tasks connected with executive functions (Peirats et al., 2019). These involve the capacity for holding and managing information (working memory), prepotent response inhibition, flexibility to task change, planning to achieve objectives, and decision-making (Goldstein et al., 2014). "These processes are critical for our daily functioning, as they enable us to carry out independent, intentional and self-directed

behaviour" (Martín et al., 2020, p.8). Authors such as Guzmán et al. (2017) state that digital resources open up a world of possibilities for working on the executive functions. The utilization of apps has therefore emerged as an interesting option, since it combines exercises for memory, organization and attention, along with entertainment and recreational activities.

The enjoyment of free time, in terms of leisure and entertainment, is vital for any person. Hence CeRMi (Spanish Committee of Representatives of Persons with Disabilities) declares that:

> [...] leisure is a fundamental right that enables the personal and social development of people and which nobody should be deprived of because of disability. It is an essential medium for attaining emotional well-being, developing interpersonal relations and promoting the inclusion of people with disabilities. (2018, p.2)

Hence providing digital options to children and adolescents with autism represents an interesting and encouraging step forward for them. Along these lines, Villén (2017) describes the experience undertaken by including the videogame *Minecraft* as "an inclusive leisure alternative for people with ASD" (p. 13).

Therefore, having reviewed the literature, we can see how there is an abundance of studies focused on the benefits of ICT and, more specifically, on the values that apps have in the development of children with autism. Considering that these technological options are presented as groundbreaking and motivating support resources for the teaching-learning process, therapy and skill development, it would be interesting and worthwhile to find out precisely what apps are being offered to this community, what content they work on and their quality. This would help to guide and structure teaching and/or psychopedagogical interventions toward specific goals with certain guarantees for success.

A simple search of the app catalogue produces hundreds of apps for people with autism, but no prior knowledge or clue as to their purpose. According to the review of studies based on apps and autism, there has been no scientific undertaking to evaluate apps specifically for this community, nor has there been an analysis of all the free apps for Android available in the Google Play Store. We therefore intend to discover and recount the number of previous apps and assess their quality and variety. Consequently, this study has the following aims:

1. To discover and calculate the number, variety and quality of apps specifically created for children with autism that exist and are available for Android.
2. To evaluate the different free apps for children with autism available on Google Play Store according to predetermined criteria of quality.
3. To offer a list of apps by area of focus for children and adolescents with autism, in order to recommend their use according to the user's need.
4. To determine which are the most specialized and which the most multifaceted apps for education and intervention with children with autism.

2 Method

2.1 Sample

For the analysis of the apps aimed at children and teenagers with autism, the Google Play Store search engine, available on mobile devices with the Android operating system, was taken as the starting point. The use of app stores for the development of research is a highly utilized resource in the international literature, and is relied upon by a range of researchers. Previous studies (Cayton et al., 2015; Comin, 2015; Crescenzi et al., 2019; Fage et al., 2018; García et al., 2016) have used app stores because they are the most popular and safest platforms for finding and downloading apps. Furthermore, the professionals and families of people with autism rely upon app stores to search for, download, install and later update these apps.

The sample comprised 155 free apps. The search terms "autismo", in Spanish, and "autism", in English, were used, thus covering the greatest number of apps in both languages. In the results section, each app appears with its name in the original language. The search was refined using rigorous pre-established exclusion criteria, which were: apps without any connection to autism; apps aimed at families or autism specialists but not specifically for people with this condition; apps with malfunctions or device incompatibilities; or apps repeated in both searches. Given the high number of apps for children with and without autism, we have only assessed those that include the keyword "autism" in their description.

2.2 Instrument

For the app evaluation, we used a "System of Indicators and Instrument for the Assessment and Selection of Apps for People with ASD", previously designed and validated by Gallardo-Montes et al. (2021c). The use of an indicator system makes it possible to evaluate in a tangible way the services offered by, in this case, the apps available on the Google Play Store. The aspects evaluated were governed by the criteria of what was necessary for an app aimed at children with autism. The proposed indicators were developed and analysed in depth from a psychopedagogical point of view, in accordance with previous studies focused on app evaluation (Araujo et al., 2007; Belloch, 2006; Cayton et al., 2015; Crescenzi & Grané, 2016; Crescenzi et al., 2019; García-Rodríguez & Gómez-Díaz, 2015; Fage et al., 2018; Larco et al., 2018). This instrument evaluated three dimensions of the apps (Table 3):

Table 3 Dimensions evaluated in the apps and indicators assessed

Dimension	Indicators
D1: Design/Form	Availability, Ergonomics, Usability, Popularity, Accessibility.
D2: Content	Audio quality, Narration quality, Content, Notifications, Help/tutorials, Safety.
D3: Pedagogical aspects	Interactivity, Suitability of pace and learning, Feedback/assessment.

The indicator system was made up of 14 items, which were in turn divided into 46 sub-indicators, depending on the dimension. The instruments gave a final score, which allowed us to rank each app as: *highly recommendable/Group 1* (≥37 points); *recommendable/Group 2* (36–23 points); or *not recommendable/Group 3* (≤22 points). The indicator system was positively assessed by a total of twelve judges with extensive experience in the education and technology field. The system obtained excellent Intraclass Correlation coefficients (ICC) ($ICC_{D1} = .955$, $ICC_{D2} = .973$ and $ICC_{D3} = .966$) and significant and strong Kendall's W inter-rater concordance (.757 and 1.00, $p < 0.001$). With a very high Cronbach's alpha coefficient ($\alpha_{D1} = .955$, de $\alpha_{D2} = .973$ y $\alpha_{D3} = .966$), this was a valid and reliable instrument.

2.3 Procedure

In order to proceed to evaluate each app, we used a conventional smartphone connected through AC Wi-Fi at a speed of 600 Mb/s, to prevent any alterations and to be able to make an assessment under equal conditions. Each app was installed on the device for two weeks and assessed progressively and thoroughly according to the indicator system, marking the presence or absence of each indicator and sub-indicator. Likewise, the area that each app worked on was indicated (communication, language, emotions, basic instrumental skills, executive functions and time management). The evaluation took place during the first quarter of 2019.

2.4 Design and data analysis

The study followed a quantitative design, taking the basic, non-experimental, simple descriptive and cross-sectional approach.

The analysis and evaluation of apps were recorded using Microsoft Office Excel 2016, indicating the area or areas they addressed (communication, language, emotions, basic instrumental skills, executive functions and time management) and writing 1 or 0 in each cell depending on the attainment or not, respectively, of the proposed indicator. Then the data were analysed with the SPSS statistical package version 25.0, with a margin of error of 5% and a reliability level of 95%. First, descriptive analysis (mean and standard deviation) was performed, as well as frequencies to find out the distribution by group, according to the quality of the apps evaluated, to determine which area(s) each app addressed, and to establish which area(s) was addressed the most and the least. Second, for the comparison between three groups of apps the univariate ANOVA - given the normality and homoskedasticity of the data - was used with the Bonferroni multiple comparisons test to define the groups in which significant differences were observed and Eta squared for estimations of the effect size. Third, to determine whether the quality of the apps depended on the areas they addressed, the chi-squared non-parametric test was used - given non-normality and homoskedasticity of the data. Finally, Pearson's correlation coefficient was calculated to establish the possible relations between the dimensions analysed, and between the different areas addressed by the apps.

3 Results

The distribution of the apps by groups was as follows: 9.03% ($n = 14$) attained the assessment for Group 1 (*highly recommendable*); 85.16% ($n = 132$) for Group 2 (*recommendable*); and 5.81% ($n = 9$) for Group 3 (*not recommendable*). Each app was examined to find out which area of work it developed.

Of the 155 apps analysed, only 1.94% ($n = 3$) focused exclusively on one single area: *"Nursery rhymes songs & kids puzzle games free"*, *"Relax melodies: sueño y yoga"* and *"The sensory processing game-autism & spd free"*, which shows the lack of specialization of the apps as a whole. These three include content linked to leisure and entertainment and belong to Group 2, *Recommendable* apps. In contrast, most apps (98.06%, $n = 152$) work on more than one area simultaneously, although none of the apps dealt with all seven proposed areas simultaneously, suggesting the need for combinations. There were four apps (2.58%) that tackled the highest number (six) of areas simultaneously: *"LEA Lecto escritura para autismo"*, *"Autastico"* (both in Group 1), *"SocialSkills for Autism Kloog 2"* and *"Tealite app"* (both in Group 2). Eleven apps (7.10%) exercised five areas at the same time, including *"Otsimo"*, which obtained the highest overall score, while 20.65% ($n = 32$) dealt with four areas at a time, including the high-scoring *"#Soyvisual"*. Finally, 44.52% ($n = 69$) handled three areas; and 17.42% ($n = 27$) involved two.

The area that was most present in the apps was communication (Table 4), appearing in 72 (46.45%): ten belonging to Group 1 (*Highly Recommendable*), 58 apps to Group 2 (*Recommendable*), and only 4 apps to Group 3 (*Not Recommendable*). In the area of language (Table 4), 91 apps (58.71%), of which 12 belong to Group 1 (*Highly Recommendable*), 75 apps to Group 2 (*Recommendable*), and 4 apps to Group 3 (*Not Recommendable*). Concerning the area of the emotions (Table 4), we found 24 apps (15.48%); only six belonging to Group 1 (*Highly Recommendable*), 18 apps to Group 2 (*Recommendable*), and none to Group 3 (*Not Recommendable*). These three areas present a direct relation with social interaction and, therefore, with ToM, and so we have shown the results jointly (Table 4), given the need to promote these areas simultaneously.

With regard to time management (Table 5), 11.61% ($n = 18$) of the apps worked on this area; just one app belonged to Group 1 (*Highly Recommendable*), 15 to Group 2 (*Recommendable*), and two to Group 3 (*Not Recommendable*).

In the area of instrumental skills (Table 6), we found 63 apps (40.65%), of which eight were included in Group 1 (*Highly Recommendable*), 53 in Group 2 (*Recommendable*), and only two in Group 3 (*Not Recommendable*).

In the area of executive functions (Table 7), 148 apps were found (95.48%), of which 14 belonged to Group 1 (*Highly Recommendable*), 128 to Group 2 (*Recommendable*), and six to Group 3 (*Not Recommendable*).

Lastly, in the area of leisure and entertainment (Table 8), 82 apps were found (52.90%), of which eight were in Group 1 (*Highly Recommendable*), 72 in Group 2 (*Recommendable*), and only two in Group 3 (*Not Recommendable*).

We can therefore state that the area of executive functions features most in the apps ($n = 148$), followed by the area related to language ($n = 91$), then leisure

Table 4 Apps focused on the Theory of Mind (communication, language and emotions)

Name of the app	TS	G	C	L	E	Name of the app	TS	G	C	L	E
1. #Soyvisual	40	1	X	X		52. Jade autism	32	2		X	
2. Otsimo	40	1	X	X		53. Ajedrez niños inf.	32	2		X	
3. Smile and Learn	39	1		X	X	54. Preescolar juegos i.	32	2		X	
4. CPA	38	1	X	X		55. El oledor	32	2	X	X	
5. Symbotalk	38	1	X	X		56. SocialSkills autism3	32	2	X		X
6. Visual schedules	37	1	X	X		57. Aprender español	32	2		X	
7. Michelzhino	37	1	X	X	X	58. Picto one	31	2	X	X	
8. LEA	37	1	X	X	X	59. Let us talk	31	2	X	X	
9. Autastico	37	1	X	X	X	60. Dictapicto	31	2	X	X	
10. Terapia z tabl.	37	1		X	X	61. Autism disease	31	2	X		
11. Emociones, se.	37	1	X	X	X	62. On tasktimer Aut.	31	2		X	
12. Commboards	37	1	X	X		63. Aprender a decir h.	31	2	X	X	
13. Proyecto emoc.	36	2	X		X	64. Emotion learning	31	2	X	X	X
14. Aboard CAA	36	2	X	X		65. ABA kit	31	2	X	X	X
15. SocialSkills	36	2	X	X	X	66. Buddy aprende n.	31	2		X	
16. Preescolar j.	36	2		X		67. Pictogramas.es	31	2	X	X	
17. Speech blubs l.	36	2	X	X		68. Buddy aprende fór.	31	2		X	
18. Socialskills aut	36	2	X	X	X	69. Matraquinha	31	2	X		X
19. Jose aprende	35	2	X		X	70. El viaje de Elisa	31	2		X	X
20. iSecuencias lite	35	2		X		71. Autism	30	2	X		
21. Proyecta pecs	35	2	X	X		72. Buddy aprende col.	30	2		X	
22. Teacch.me	35	2	X	X		73. Action words 3d an.	30	2		X	
23. Comuniquem.	35	2	X	X		74. Help talk	30	2	X	X	
24. Vi.co hospital	35	2	X	X		75. Mousetrial lite	30	2		X	
25. Lista visual	35	2	X	X		76. Conciencia fonológ.	29	2	X	X	
26. Visual reading	35	2	X	X		77. Autismo imagen d.	29	2	X	X	X

Table 4 (continued)

Name of the app	TS	G	C	L	E
27. ABA drOm.	35	2		X	X
28. Asistente voz	35	2	X	X	
29. Proyecto retr.	34	2		X	X
30. Pictotea	34	2	X	X	
31. Autimo	34	2	X	X	X
32. Diegosays aut.	34	2	X	X	
33. LEELOO AAC	34	2	X	X	
34. Talk up! Com.	34	2	X	X	
35. Palabras para	34	2	X	X	
36. Alfabeto escrit.	34	2		X	
37. Niño alfabeto	34	2		X	
38. Horsy	34	2		X	
39. Abc aut	33	2	X	X	
40. Letmetalk	33	2	X	X	
41. Emoplay	33	2	X	X	X
42. Tealite app	33	2	X	X	X
43. Cabrito ortogr.	33	2		X	
44. Preescolar apr.	33	2		X	
45. Autism help	33	2	X	X	
46. Letra a letra	33	2		X	
47. Tarjetas educ.	33	2		X	
48. Pictogramas.es	32	2	X	X	
49. Daily tasks	32	2	X		
50. Autismo help	32	2	X	X	

Name of the app	TS	G	C	L	E
78. Talking pictures au.	29	2	X	X	
79. App4autism - timer	29	2	X		
80. Pictodroid lite	29	2	X	X	
81. Niki Talk	28	2	X	X	
82. Dialogo AAC lite	28	2	X	X	
83. Aprender cabrito fr.	28	2		X	
84. Pictogramagenda	28	2	X	X	
85. Talking pictures	28	2	X	X	
86. Jabtalk	28	2	X	X	
87. Conversation ther.	28	2	X	X	X
88. Articulation speech	27	2	X	X	
89. Upcard	27	2	X	X	
90. Diego dice	26	2	X	X	
91. Special app CAA	26	2	X	X	
92. Petterday agenda p	25	2	X	X	
93. Talk to me 100@	25	2	X	X	
94. Autistic bird	24	2	X	X	
95. Autapp - autismo	24	2		X	X
96. говори молча	24	2	X		
97. Piktosaac pictogr.	22	3	X	X	
98. Autismcpm	19	3	X	X	
99. Speak through pict.	19	3	X	X	
100. Autism mindawak.	16	3			
101. Autism helper lite	16	3	X		

Table 4 (continued)

Name of the app	TS	G	C	L	E	Name of the app	TS	G	C	L	E
51. Autismo lee	32	2		X							

TS = Total score; G = Group; C = Communication; L = Language; E = Emotions

Table 5 Apps focused on time management

Name of the app	TS	G	Name of the app	TS	G
1. Visual schedules social stor.	37	1	**10.** I'm on it focus timer	29	2
2. Lista visual - visual schedule	35	2	**11.** Pictogramagenda	28	2
3. Tempus	33	2	**12.** Conversation therapy lite	28	2
4. Social skills for autism 3	32	2	**13.** Upcard	27	2
5. Proyect@ habilidades	31	2	**14.** Petterday agenda pictogramas	25	2
6. On tasktimer-utism timer	31	2	**15.** Kids timer	25	2
7. Aprender a decir la hora	31	2	**16.** Temporizador para niños timer	25	2
8. Children countdown timer	29	2	**17.** In2token (Autism Token Boa.)	20	3
9. App4Autism timer, visual	29	2	**18.** Visual time timer	19	3

TS = Total score; G = Group

and entertainment in third ($n = 82$), communication in fourth ($n = 72$), and basic instrumental skills in fifth ($n = 63$). The areas dealt with the least were the emotions ($n = 24$) and time management ($n = 18$). From these frequencies, illustrated in Fig. 1, we can infer the needs of apps for users with ASD.

Additionally, the average quality of the apps can be affirmed as "*Recommendable*" ($\bar{x} = 2.03$, 85.16%) (Fig. 2). They did not attain the utmost quality of "*Highly Recommendable*" (only 9.03%), but neither did they fall into the worst category, with only 5.81% forming the "*Not Recommendable*" group.

Differences were found regarding the above app rating by groups (1, 2 and 3), according to the ANOVA calculation ($F(2) = 61.20$), which produced significant differences ($p = .000$) with a medium effect size ($\eta^2 = .45$). The differences were significant between all the groups, as the Bonferroni post-hoc tests showed ($p = .000$ in all cases), showing heterogeneous subsets. Therefore, not all the apps are valid; users should choose them carefully.

Regarding the evaluation by dimension, only dimensions 2 (on "content") and 3 (on "pedagogical aspects") were matched, with a notable correlation, direct ($r = .57$) and significant ($p = .000$). In contrast, the relation of these dimensions with dimension 1 (on "design and form") was low ($r_{D1-D2} = .21$, $p = .008$ and $r_{D1-D3} = .17$, $p = .031$).

The quality of the apps does not depend on the areas they work on, as demonstrated by the Chi-squared test ($\chi^2 = 5.56$; $p = .011$), thus accepting the null hypothesis of no relationship between evaluations of the apps. In other words, apps of different quality can be found in every area, meaning that they should be evaluated before being employed in any particular area.

Furthermore, the apps analysed are clearly oriented toward certain areas. They are not comprehensive, thus adding to the aforementioned requirement the need for each user to have a clear work objective before arbitrarily using the apps. Indeed, of all the areas observed in the apps, only "communication" and "language" have a direct and significant relationship ($r = .52$, $p = .000$), while "leisure" and "instrumental skills" are indirectly and significantly related ($r = .47$, $p = .000$).

Table 6 Apps focused on basic instrumental skills

Name of the app	TS	G	Name of the app	TS	G
1. #Soyvisual	40	1	**33.** Tarjetas educativas español	33	2
2. Otsimo	40	1	**34.** Autismo lee y escribe gratis	32	2
3. MITA	39	1	**35.** Jade autism	32	2
4. Smile and Learn	39	1	**36.** Niño juego de memoria alim.	32	2
5. LEA Lecto escritura	37	1	**37.** Games for kids sea animals	32	2
6. Autastico	37	1	**38.** Ajedrez niños infantil gratis	32	2
7. Juegos de niños para bebes	37	1	**39.** Rompecabezas de niños din.	32	2
8. Terapia z tabletem	37	1	**40.** Baby piano games & music	32	2
9. SocialSkills Autism Kloog 2	36	2	**41.** Aprender español para niños	32	2
10. Preescolar juegos en españ.	36	2	**42.** Aprender a decir la hora	31	2
11. Isecuencias lite	35	2	**43.** Buddy aprende los numeros	31	2
12. Visual Reading educacion	35	2	**44.** Buddy aprende las formas	31	2
13. Rompecabezas puzzingo	35	2	**45.** Buddy aprende los colores	30	2
14. Niños de dibujo animado	35	2	**46.** Autism speech sequencing	30	2
15. Animals puzzle for kids	35	2	**47.** Kids puzzle car & vechicles	30	2
16. Fotos de animales romp.	35	2	**48.** Vehicles puzzle for kids	30	2
17. Vechicles puzzle for kids p.	35	2	**49.** MouseTrial Lite	30	2
18. ABA DrOmnibus for Par.	35	2	**50.** Conciencia fonologica	29	2
19. Rompecabezas dinosaurios	34	2	**51.** Autismo imagen discusión	29	2
20. Palabras para niños	34	2	**52.** Autsim exit vn	29	2
21. Alfabeto escrito ABC 123	34	2	**53.** Romp. niños-habilidades m.	29	2
22. Animal rompecabezas	34	2	**54.** Aprender cabrito fruta	28	2
23. De suma y resta niños	34	2	**55.** Games for kids wild animals	28	2
24. Niño alfabeto de aprendizaje	34	2	**56.** Puzzles de animales para niños	28	2
25. Gratis niños juego de puzzle	34	2	**57.** Games for kids retro cars	27	2
26. ABC Autismo	33	2	**58.** Special app CAA	26	2
27. Tealite app	33	2	**59.** Puzzles de frutas para niños	25	2
28. Niño conectar los puntos	33	2	**60.** Focus	25	2
29. Cabrito juego de ortografia	33	2	**61.** Games for kids modern cars	23	2
30. Preescolar aprende numeros	33	2	**62.** Autismcpm	19	3
31. Dinosaurios rompecabezas	33	2	**63.** Autism mindawakener	16	3
32. Letra a letra - deletrear	33	2			

TS = Total score; G = Group

4 Discussion and conclusions

Smartphones and tablets are used frequently in the teaching-learning process, in therapy and in the family context of children and adolescents with autism. The use of electronic devices is an encouraging and attractive option for children with autism, due to the auditory and visual format that they often offer. Faced with the imminent technological proliferation of content addressed to minors with this

Table 7 Apps focused on executive functions

Name of the app	TS	G	Name of the app	TS	G
1. #Soyvisual	40	1	**75.** Social skills for autism 3 Kloogs	32	2
2. Otsimo	40	1	**76.** Baby piano games & music	32	2
3. MITA	39	1	**77.** Aprender español para niños	32	2
4. Smile and Learn	39	1	**78.** Picto one	31	2
5. CPA	38	1	**79.** Let us talk	31	2
6. SymboTalk - AAC Talker	38	1	**80.** Dictapicto	31	2
7. Visual schedules and social	37	1	**81.** Autism disease	31	2
8. Michelzhino- emoçoes	37	1	**82.** Proyect@ habilidades	31	2
9. LEA Lecto escritura	37	1	**83.** On tasktimer-utism timer	31	2
10. Autastico	37	1	**84.** Aprender a decir la hora	31	2
11. Juegos de niños para beb.	37	1	**85.** Emotion learning for autistic	31	2
12. Terapia z tabletem	37	1	**86.** ABA kit	31	2
13. Emociones, sentimientos	37	1	**87.** Buddy aprende los numeros	31	2
14. CommBoards-gratis	37	1	**88.** Pictogramas.es	31	2
15. Proyecto emociones	36	2	**89.** Buddy aprende las formas	31	2
16. Aboard CAA	36	2	**90.** Matraquinha	31	2
17. SocialSkills Autism 2	36	2	**91.** El viaje de Elisa	31	2
18. Preescolar juegos en esp.	36	2	**92.** Autism	30	2
19. Quien es quien	36	2	**93.** Buddy aprende los colores	30	2
20. Speech Blubs: Language	36	2	**94.** Autism speech sequencing zapps	30	2
21. SocialSkills for Autism	36	2	**95.** Kids puzzle car & vechicles	30	2
22. Jose aprende	35	2	**96.** Vehicles puzzle for kids	30	2
23. Isecuencias lite	35	2	**97.** Action Words: 3D Animated	30	2
24. Proyecta PECS	35	2	**98.** Help talk	30	2
25. Teacch.me	35	2	**99.** MouseTrial Lite	30	2
26. Comuniquemonos	35	2	**100.** Conciencia fonologica	29	2
27. Vi.co hospital lite	35	2	**101.** Autismo imagen discusión	29	2
28. Lista visual - visual	35	2	**102.** Autsim exit vn	29	2
29. Visual Reading educacion	35	2	**103.** Talking pictures autism pc	29	2
30. Rompecabezas puzzingo	35	2	**104.** Children countdown timer	29	2
31. Niños de dibujo animado	35	2	**105.** Rompecabezas niños hab.	29	2
32. Animals puzzle for kids	35	2	**106.** App4Autism - timer, visual	29	2
33. Fotos de animales romp.	35	2	**107.** I'm on it: focus timer	29	2
34. Vechicles puzzle for kids	35	2	**108.** Pictodroid lite	29	2
35. ABA DrOmnibus for Par.	35	2	**109.** Preschool bus driver toddler	29	2
36. Asistente de voz AAC	35	2	**110.** Niki Talk	28	2
37. Proyecto Retratos	34	2	**111.** Dialogo AAC Lite Autism	28	2
38. Pictotea	34	2	**112.** Aprendizaje sensorial de niños	28	2
39. Autimo	34	2	**113.** Sonidos animales para niños	28	2
40. Diegosays autismo habla	34	2	**114.** Piano para bebés: juego	28	2
41. Leeloo AAC - Autism	34	2	**115.** Dibujos de arena - sand draw	28	2
42. Talk up! communicator	34	2	**116.** Aprender cabrito fruta	28	2

Table 7 (continued)

Name of the app	TS	G	Name of the app	TS	G
43. Rompecabezas de din.	34	2	**117.** Games for kids wild animals	28	2
44. Palabras para niños	34	2	**118.** Puzzles de animales para niños	28	2
45. Alfabeto escrito ABC 123	34	2	**119.** Sensory baby: games for babies	28	2
46. Animal rompecabezas b.	34	2	**120.** Pictogramagenda	28	2
47. De suma y resta niños	34	2	**121.** Talking pictures: autism, cp	28	2
48. Niño alfabeto	34	2	**122.** Jabtalk	28	2
49. Horsy	34	2	**123.** Conversation therapy lite	28	2
50. Gratis niños juego	34	2	**124.** Kids tap and color (lite)	28	2
51. ABC Autismo	33	2	**125.** Games for kids retro cars	27	2
52. Tempus	33	2	**126.** Articulation speech theraphy	27	2
53. Letmetalk	33	2	**127.** Upcard	27	2
54. Emoplay	33	2	**128.** Special app CAA	26	2
55. Tealite app	33	2	**129.** Petterday agenda pictogramas	25	2
56. Niño conectar los puntos	33	2	**130.** Puzzles de frutas para niños	25	2
57. Cabrito juego de ortogr.	33	2	**131.** Talk to me 100® Lite - Autism	25	2
58. Preescolar aprende num.	33	2	**132.** Kids timer	25	2
59. Dinosaurios rompec.	33	2	**133.** Focus	25	2
60. Autism help	33	2	**134.** Temporizador para niños	25	2
61. Letra a letra - deletrear	33	2	**135.** Comunicatea hus/surestea	24	2
62. Tarjetas educativas	33	2	**136.** AutApp - Autismo	24	2
63. Pictogramas.es	32	2	**137.** Говори молча: аутизм ДЦП	24	2
64. Daily tasks	32	2	**138.** Autistic bird	24	2
65. Autismo help	32	2	**139.** Autism sensory images	24	2
66. Autismo lee y escribe	32	2	**140.** Games for kids modern cars	23	2
67. Jade autism	32	2	**141.** Sensory	23	2
68. Puzzles para niños preesc.	32	2	**142.** Pensar e facer	22	3
69. Niño juego de memoria	32	2	**143.** Piktosaac pictogramas autismo	22	3
70. Games for kids sea	32	2	**144.** In2token (Autism Token B.)	20	3
71. Ajedrez niños infantil	32	2	**145.** Visual time timer	19	3
72. Preescolar juegos infant.	32	2	**146.** Speak through Pictures-Autism	19	3
73. Rompecabezas de niños	32	2	**147.** Autism mindawakener	16	3
74. El Oledor	32	2	**148.** Autism helper lite	16	3

TS = Total Score; G = Group

disorder, it was necessary to analyse what is really being offered to this group, since many professionals and families use devices of this kind on a daily basis and they depend upon the apps to foster the development of deficient skills (communication, emotions, time management, basic instrumental skills, executive functions and leisure/entertainment).

Table 8 Apps focused on leisure and entertainment

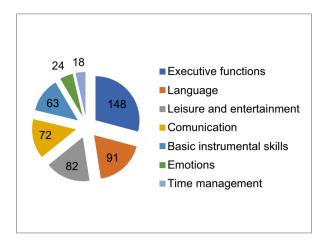| Name of the app	TS	G	Name of the app	TS	G
1. Otsimo	40	1	**42.** El Oledor	32	2
2. MITA	39	1	**43.** Social skills for autism 3 Kloogs	32	2
3. Smile and Learn	39	1	**44.** Baby piano games & music	32	2
4. LEA Lecto escritura	37	1	**45.** Aprender español para niños Cog.	32	2
5. Autastico	37	1	**46.** Buddy aprende los numeros	31	2
6. Juegos de niños bebes	37	1	**47.** Buddy aprende las formas	31	2
7. Terapia z tabletem	37	1	**48.** El viaje de Elisa	31	2
8. Emociones, sentimientos	37	1	**49.** Buddy aprende los colores	30	2
9. Proyecto emociones	36	2	**50.** Autism speech sequencing zapps	30	2
10. SocialSkills Autism 2	36	2	**51.** Kids puzzle car & vechicles	30	2
11. Preescolar juegos esp.	36	2	**52.** Vehicles puzzle for kids	30	2
12. Quien es quien	36	2	**53.** Action Words: 3D Animated	30	2
13. Speech Blubs: Lang.	36	2	**54.** MouseTrial Lite	30	2
14. SocialSkills for Autism	36	2	**55.** Conciencia fonologica	29	2
15. Isecuencias lite	35	2	**56.** Autismo imagen discusión	29	2
16. Rompecabezas puzz.	35	2	**57.** Autsim exit vn	29	2
17. Niños de dibujo anim.	35	2	**58.** Rompecabezas niños-habilidades	29	2
18. Animals puzzle	35	2	**59.** Preschool bus driver toddler g.	29	2
19. Fotos de animales	35	2	**60.** Relax melodies: sueño y yoga	29	2
20. Vechicles puzzle	35	2	**61.** Aprendizaje sensorial de niños	28	2
21. ABA DrOmnibus par.	35	2	**62.** Sonidos animales para niños	28	2
22. Rompecabezas de din	34	2	**63.** Piano para bebés: juego	28	2
23. Alfabeto escrito ABC	34	2	**64.** Dibujos de arena - sand draw	28	2
24. Animal rompecabezas	34	2	**65.** Aprender cabrito fruta	28	2
25. Horsy	34	2	**66.** Games for kids wild animals	28	2
26. Gratis niños juego	34	2	**67.** Puzzles de animales para niños	28	2
27. Tealite app	33	2	**68.** Sensory baby: games for babies	28	2
28. Niño conectar los puntos	33	2	**69.** Kids tap and color (lite)	28	2
29. Cabrito juego de ortogr.	33	2	**70.** Games for kids retro cars puzzles	27	2
30. Preescolar aprende num.	33	2	**71.** The sensory processing game	26	2
31. Dinosaurios romp.	33	2	**72.** Puzzles de frutas para niños	25	2
32. Autism help	33	2	**73.** Focus	25	2
33. Tarjetas educativas	33	2	**74.** AutApp - Autismo	24	2
34. Nursery rhymes songs	33	2	**75.** Autistic bird	24	2
35. Pictogramas.es	32	2	**76.** Autism sensory images	24	2
36. Puzzles para niños romp.	32	2	**77.** Games for kids modern cars	23	2
37. Niño juego de memoria	32	2	**78.** Sensory	23	2
38. Games for kids sea	32	2	**79.** Fidget Stress buster	23	2
39. Ajedrez niños infantil	32	2	**80.** Pensar e facer	22	3
40. Preescolar juegos infant.	32	2	**81.** _good_Fidget_Spinner_5891977	21	3
41. Rompecabezas de niñ.	32	2	**82.** Autism mindawakener	16	3

TS = Total Score; G = Group

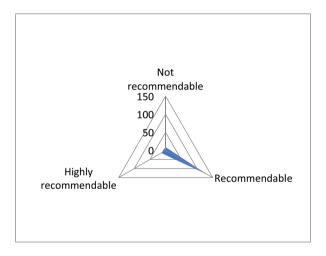**Fig. 1** Frequency of apps that present each of the areas worked on

Fig. 2 Rating of the apps overall, assessed for autism

The evaluation of apps for children and adolescents with autism requires in-depth analysis that examines content, design and pedagogical aspects, scrutinizing each app's peculiarities, which should be in keeping with the user's needs.

These days, accessing apps is relatively simple, but selecting which best fit the user's characteristics and needs is not, particularly for families. As Xanthopoulou et al. (2019) and Hanna et al. (2021) point out, no guidance exists for the selection and use of apps. This study will therefore facilitate this selection, since despite specifying a great variety of apps, it clearly shows which areas each one addresses and their overall quality, helping to make searching simpler and more intuitive, and increasing the possibility of finding the required content quickly.

In general terms, the results obtained with this evaluation are encouraging, given the heterogeneity of the apps and the variety of different designs observed. Few apps have obtained an assessment of "*not recommendable*", since most apps were found in the "*recommendable*" group, with an average quality – as Hanna et al. (2021) also found in their study – but with potential for improvement in terms of quality, design, pedagogic aspects and content aimed at children and adolescents with autism. Furthermore, these results are in agreement with the findings of Dattolo and Luccio (2017) and Lian and Sunar (2021), which show that the design and content could be improved, as they were not wholly adapted to the needs and characteristics of people with ASD.

The study revealed the large variety of apps and the enormity of content they offer. Nonetheless, we can highlight several aspects. The apps that based their content on the development of executive functions were the most numerous, being present in 148 apps. This shows current knowledge on the need to promote this area from an early age and throughout the person with autism's development, which authors such as Guzmán et al. (2017) and Peirats et al. (2019) highlight in their studies. Of these 148 apps, only 8 have scientific evidence on the improvements produced in the area of the executive functions in users (Aguilar-Velázquez et al., 2020; Jiménez et al., 2017; Sung, 2018; Vyshedskiy et al., 2020): "*MITA*", "*CPA*" and "*LEA Lecto escritura para autismo*" from the "*highly recommendable*" group, and "*SocialSkills for Autism Kloog 2*", "*LetMeTalk*", "*Autism help*", "*Pictodroid lite*" and "*Niki Talk*" from the "*recommendable*" group. Studies such as that by Teixeira and Cunha (2019) also show progress in the increase in attention and behaviour through the use of the app "*123 Autismo*", which was not included in this study.

The apps linked to ToM were highly represented ($n = 101$), showing an average quality, whereas in the study by Crespo and Martín (2018) they were considered optimal for children with autism. Along the same lines, Adamu et al. (2019) show that the apps addressing communication had interfaces that were tied to the child's characteristics. Previous studies indicate progress in the prerequisites of language, communicative intent and behaviour through the use of the apps "*CPA*" and "*LEA Lecto escritura para autismo*" (both "*highly recommendable*"), and "*LetMeTalk*", "*Autism help*" "*Pictodroid Lite*" and "*Niki Talk*" (from the "*recommendable*" group) (Aguilar-Velázquez et al., 2020; Jiménez et al., 2017; Sung, 2018). Lázaro-Cantabrana et al. (2019) show improvements in the understanding of information, and capacity for expression and communication through the app "*SOS TEA*", which was not analysed in this study. However, the apps that focused on the development of emotions were not predominant in the app catalogue. They mostly fell into the "*recommendable*" group, and none were "*not recommendable*". The imbalance between these apps and the rest was striking. Despite this, the apps available did not obtain bad scores or evaluations. Indeed, authors such as Matey (2017) and González et al. (2016) highlight the encouraging results from the use of mobile apps linked to the emotional sphere.

Likewise, with time management, wherein most of the apps addressing it attained a *recommendable* rating. It seems curious that aspects connected to ToM (Premack & Woodruff, 1978), such as the emotions and time management, routine establishment and task organization, appear so infrequently compared to the rest of the app

catalogue. These areas should be fostered from an early age, given that they are necessary for social interaction itself. Although their number is few, it is encouraging that these apps obtained a good assessment, and can be used effectively and successfully by families, teachers and autism specialists.

The development of basic instrumental skills was included in 63 of the apps assessed, and this was one of the aspects utilized in previous studies, with benefits gained from their use. Examples of these include "*MITA*", rated as "*highly recommendable*" (Vyshedskiy et al. 2020); "*LEA Lecto escritura para autismo*", also "*highly recommendable*" (Aguilar-Velázquez et al., 2020); and "*SocialSkills for Autism Kloog 2*", assessed as "*recommendable*" (Sung, 2018). Other studies, such as those by Teixeira and Cunha (2019) with the app "*123 Autism*", Sweidan et al. (2019) with "*Autistic Innovate Assistant (AIA)*", and Lázaro-Cantabrana et al. (2019) with the app "*SOS TEA*" (not evaluated here), also show successful results in the development of the basic instrumental skills, with progress in mathematical, linguistic and communicative skills.

Regarding the apps for leisure and entertainment, we observe an increase in their presence in the digital app market, in contrast to the study by Crespo and Martín (2018), who report their limited presence and lack of representation, and call for research and development in this area. However, we have not found any scientific evidence on the use of apps for the enjoyment of leisure and free time in children with autism.

Most apps did not focus on one single area, as in the study by Crespo and Martín (2018), making them more functional and multifaceted, but, consequently, not specialized. The two apps with the highest ratings, "*#Soyvisual*" and "*Otsimo*", work, respectively, on four and five areas simultaneously, which means that with a single app different areas are addressed, with content, design and pedagogical approach of quality. Other apps, also high-scoring, included even more areas in their content, such as "*LEA Lecto escritura para autismo*" and "*Autastico*" (both rated as *highly recommendable*), and "*SocialSkills for Autism Kloog 2*" o "*Tealite app*" (both *recommendable*). The quality of the apps did not depend on the areas they worked on, and so we must not assume that all apps are equal; not all apps are valid and they should be chosen with care. The use made of the apps will depend on the aims set by teachers, specialists, and families, as well as on the activity, the content sought and the characteristics of the users.

As was to be expected, the apps that revolve around the area of communication and language revealed a direct relationship. These areas have a strong connection in human interaction, since even though communication encompasses a broad spectrum of expressions (eye contact, gestures, etc.), the presence of a functional language gives it value and meaning. These aspects can be observed in Jiménez et al. (2017): after using mobile devices for this purpose, the communicative processes and language production increased. As has been seen, many apps worked on both topics jointly, and different forms of task and content can be found, depending on the developmental stage of the child or the context in which learning is managed and undertaken.

The purpose of any proper intervention should be aimed at the comprehensive development of the person with autism. Thus, as has been evident throughout the

study, the apps are set up as a constantly changing and updated resource, according to the needs and requirements of the educational system and the practices involved in psychopedagogical intervention. In turn, given the active participation of the family as essential actors in the raising and development of the child with autism, ICT resources such as apps are available to everyone who wishes to make use of them. Times have changed, and with them the way that families help and provide resources to their children. The content of apps not only aims to provide accessibility to people with functional diversity, but also include tutorials and instructions for family members, with intuitive and easy-to-manage designs. However, in the apps specifically for children with autism, these tools were only found in a minority (written tutorials: 24.5%, $n = 38$; audio tutorials: 9.03%, $n = 14$). This lack was also noted by Cayton et al. (2015) and Hanna et al. (2021), the latter stating that contents need to be presented to families in a clear way in order for the orientation and guided use with family members with ASD to be successful.

It was clear, from the analysis undertaken, that when an app is being designed for children with autism, the specialist teams (educators and programmers) need to work together from the beginning of the process to agree on the specific requirements of this group and the options an app can offer, and, when possible, to seek input from the children and teenagers with autism themselves (Fletcher-Watson et al., 2016), or at least with their carers, to ensure that the content is appropriate. As we have seen, there was little relation between the "design/form" dimension and the "content" and "pedagogical aspects" dimensions. This lack of relation could cause dissatisfaction for everyone involved, but particularly among users. In order to overcome difficulties and obstacles, consideration should be given to the Web Content Accessibility Guidelines (WCAG) proposed by the World Wide Web, known as W3C (Lawton, 2005). Close collaboration between teams is also essential to produce better app functionality. Previous studies, such as Sofian et al. (2016, 2018), Sanromà-Giménez et al. (2021) and Gallardo-Montes et al. (2021b), argue precisely for the attention that should be given to the criteria linked to an app's appearance, its usability, accessibility and its pedagogical aspects. The criteria considered in the three dimensions mentioned above could serve not only for their analysis but also as basic guidelines for app creation. Web tools could even be created for prior, online evaluation to see whether an app meets the preestablished dimensions and criteria. This type of tool already exists for other dimensions, such as for assessing website accessibility for people with visual impairment and other specific characteristics, as provided by the Siteimprove Accessibility Checker. Ultimately, the aim is to lessen the barriers to learning and participation faced by some people with functional diversity.

As well as the suitable creation of apps, in terms of their specific use, we recommend that guidance on how to select and use apps be included in both initial and lifelong training in pedagogical-didactic and digital competences, in accordance with criteria such as the above, for teachers, educators and other professionals who work with children with autism. Neither should it be forgotten that close collaboration between schools and families is not only an advantage but a necessity (Xanthopoulou et al., 2019). Establishing user profiles and also profiles for carers or supervisors (teacher, educator, family members, etc.) could foster a more personalized use that is tailored to the needs of the child with autism. We also advise families and

professionals to monitor the apps before offering them to children (Xanthopoulou et al., 2019). And, of course, it is very important that consideration be given when selecting apps for use with children and adolescents with autism to those that are based on scientific principles and/or supported by empirical research (Allen et al., 2016). This is still a hard task, as most apps have not yet been backed by scientific evidence on their validity and efficacy (Crespo & Martín, 2018). It is therefore crucial for there to be collaboration between researchers and teaching and/or multiprofessional teams that use the apps in their work with children with autism. This will facilitate the study and dissemination of their experience and findings, with an emphasis not only on the benefits obtained but also on the difficulties encountered and the potential options to overcome them.

A possible limitation of this study is that there are still few studies on the evaluation of apps for children with autism. Furthermore, in some of the previous studies, they evaluate apps other than those analysed here – the criteria for evaluation are different or the studies are systematic reviews, which makes it difficult to compare results. Yet this also means that this study fills a gap in the research. Another limitation of the study concerns the exclusion of apps developed for other operating systems (iOS, Harmony, etc.), as well as apps that require purchase, since our assessment focuses exclusively on free apps for Android available on the Google Play Store.

In terms of future research, it would be interesting to find out what use both professionals who work with children with ASD and families are actually making of apps. This will make it possible to know whether the best apps are really the most used, if they meet users' needs and the stipulated aims, as well as whether they prove to be intuitive to use (as one would hope), or whether, in contrast, they prove difficult. It would also be worthwhile to assess to what degree an app proves recommendable if it is analysed from the perspective of the quality of the area it addresses.

This study aims to be a novel tool to guide specialists, teachers and families in choosing the best apps for children with autism, according to the content to address and the characteristics of the user. It also sets out to indicate what aspects need improvement in app design, which programmers could bear in mind to enhance accessibility and functionality. Together, this would help apps to become an optimal resource for children with autism.

Code availability Not applicable.

Declarations

Ethics approval Not aplicable.

Consent to participate Not aplicable.

Consent for publication The authors consent to the publication of the results described in the article.

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