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27

28 **Abstract**

29 **Purpose** The purpose of this systematic review was to identify, appraise and critically synthesize
30 the latest available evidence on the effects in communication skills of AAC based interventions
31 in children from 6 to 10 years old with mixed diagnoses.

32 **Methods:** MEDLINE (OVID), PsycINFO (EBSCO), ERIC (ProQuest), SCIELO (WOS),
33 Teacher Reference Center (EBSCO) and Education Database (ProQuest) were searched. Studies
34 were selected independently by two reviewers according to the purpose of the review.
35 Methodological quality of the included studies was assessed and characteristics and results of the
36 studies were extracted.

37 **Results:** 14 studies were included in this review, of the 1204 found through the electronic
38 search. The AAC interventions studied were effective at improving various outcomes in children
39 with mixed diagnoses. Interventions that focused on narrative skills were the most common type.
40 When considering the studies' quality, independence of assessors, data analysis, replication and
41 generalization of interventions were weaker areas.

42 **Conclusions:** Training in narrative skills appears to be an important issue to address at this age.
43 A child's preferred AAC method should be taken into account when planning an intervention.

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47 The American Speech-Language-Hearing Association (ASHA), in the “Guidelines for
48 Meeting the Communication Needs of Persons With Severe Disabilities” (1992) recognizes a
49 Communication Bill of Rights that explicitly states: “All persons, regardless of the extent or
50 severity of their disabilities, have a basic right to affect, through communication, the conditions
51 of their own existence” (p. 42). That means all human beings have the right to communicate and
52 to access the tools necessary to ensure it.

53 Augmentative and Alternative Communication (AAC) is an area of research and a set of
54 clinical and educational practices that “involves attempts to study and when necessary
55 compensate for temporary or permanent impairments, activity limitations, and participation
56 restrictions of individuals with severe disorders of speech-language production and/or
57 comprehension, including spoken and written modes of communication” (ASHA, 2005, p.1).
58 Therefore, AAC incorporates tools and strategies (such as symbols, pictures, and speech-
59 generating devices) that an individual may use to solve everyday communication challenges
60 (ISAAC, 2018).

61 There are a huge variety of AAC forms. Firstly, a distinction should be drawn between
62 unaided and aided AAC systems (Nan et al., 2018). Unaided systems do not require any external
63 tools and included gestures, vocalizations and sign languages (Moorcroft et al., 2018). Aided
64 AAC systems require devices, which may or may not be electronic, for the user to transmit or
65 receive a message (ASHA, 2005; Simacek et al.,2017). Aided AAC methods can be low- or
66 high-tech: Low-tech AAC systems do not need batteries, electronic devices or electricity.
67 Examples of such methods are boards, books, etc. from which the user can select a word, letter,
68 pictogram or symbol to effectively communicate (Moorcroft et al., 2018). High-tech AAC
69 methods normally use electronic devices to communicate. For example, to allow prediction and

70 synthesize text-to-speech output, in addition to digitized recordings, e-mails, or computer and
71 device outputs, and a host of additional computer functions, which are often collectively referred
72 to as Voice Output Communication Aids (VOCAs) or Speech Generating Devices (SGDs)
73 (Simacek et al., 2017). However, recent research has not proved that high-tech AAC systems are
74 significantly more effective than low-tech AAC systems for teaching social-communication
75 skills (Morin et al., 2017). Similarly, the scientific community affirms that there are clearly
76 advantages and disadvantages to both aided and unaided AAC systems (Simacek et al., 2017).
77 Therefore, an individualized comparison of systems is usually recommended for each case
78 (Johnston et al., 2012).

79 Nevertheless, it must be highlighted that in the last decade the availability of high-tech
80 AAC has increased substantially (Banda & Alzrayer, 2018). That is, with the development of
81 information and communication technology (ICT), high-tech AAC has rapidly evolved and there
82 are now a vast number of high-tech AAC methods using a variety of computer programs and
83 mobile/tablet apps (Gilroy et al., 2017). Moreover, these technological advances also allow for
84 the adaptation of AAC methods and devices, providing many different options for users from
85 different backgrounds and incomes (Kulkarni & Parmar, 2017). These devices are also more
86 attractive to children and teenagers (Rashid & Nonis, 2015). Thus, all these elements have been
87 important in the improvement of the lives of people with complex communication needs (CCN).

88 Evidence of the potential benefits of AAC for a variety of populations has also expanded
89 the numbers of individuals with significant communication disabilities who use AAC methods in
90 recent years (Light & McNaughton, 2012). Scientific evidence has shown that the AAC is of
91 significant benefit not only for people who have no functional speech, but also for children who
92 are at risk of not speaking, or who may only speak later in their development, and for people who

93 have speech that is difficult to understand (Baumann Leech, & Cress, 2011; Braddock et al.,
94 2012; Calculator & Black, 2010; Light & Drager, 2012; Ronski et al., 2010; Sigafoos et al.,
95 2011). That is, people who have severe speech or language difficulties may use AAC methods to
96 occasionally or permanently communicate. Children who use AAC have diverse diagnoses,
97 including cerebral palsy, autism spectrum disorder (ASD), developmental verbal dyspraxia,
98 aphasia, locked-in syndrome or any intellectual impairment that affects communication (ISAAC,
99 2018). This variety of pathologies is a key concern when analyzing AAC methods, since these
100 must respond to a wide variety of CCN.

101 Additionally, the age of the participants plays a key role in their needs and the
102 intervention's characteristics. A child's communicative needs and complexities are different
103 across different stages of their development. Concretely, during school years, children
104 investigate the equivalencies of speech and writing as they weave together their experiences of
105 play, writing, talking, and drawing (Gillam & Johnston, 1992). Several studies have analyzed
106 AAC interventions in early childhood (Branson & Demchak, 2009; Solomon-Rice & Soto,
107 2014), a phase in which linguistic competence begins to be acquired, but little is known about the
108 next phase. Research indicates that language skill is directly linked to the development of social
109 competence in school-aged children (Gallagher, 1993). Indeed, elementary school-aged children
110 (6-10 years) with physical disabilities and complex communication needs reported higher levels
111 of enjoyment and preference for activity participation (Thirumanickam et al., 2011). However,
112 they engaged in activities with reduced variety, lower frequency, fewer partners and in limited
113 venues, demonstrating that the impact of severe communication difficulties on their participation
114 and socialization is substantial (Gallagher, 1993). So, communication skills seems to be of vital
115 importance during this stage for the development of social skills and the socialization of

116 children. Therefore, from an inclusive perspective, it is essential to be able to ensure this optimal
117 socialization (Rafferty et al., 2003).

118 Henceforth, the variety of AAC methods used along with the variety of characteristics
119 people with CCN show (i.e. age, diseases, diagnoses, skill levels of participants etc.) make it
120 difficult to legitimately consider some approaches included here as “best practice” (Allen et al., ,
121 2017) for each target population. Research and systematic reviews conducted strictly with
122 children diagnosed with ASD or cerebral palsy have been plentiful in recent years (Holyfield et
123 al., 2017; Karlsson et al., 2018; Logan et al., 2016; Novak et al., 2012; Pennington et al., 2004;
124 Pennington et al., 2005; Schlosser & Wendt, 2008; Sievers et al., 2018). However there is a lack
125 of knowledge of the characteristics and effects of interventions on demographics with other
126 diagnoses or with mixed diagnoses.

127 Therefore, the aim of this study is to identify, appraise and critically synthesize the latest
128 available evidence regarding AAC interventions in children from 6 to 10 years old with mixed
129 diagnoses and determine which interventions are effective through systematic review.

130 **Methods**

131 This systematic review was designed and conducted following the Cochrane
132 Collaboration Manual for Systematic Reviews (version 5.0.1) (Higgins & Green, 2011). This
133 manuscript has been drawn up using PRISMA (Preferred Reporting Items for Systematic
134 Reviews and Meta-Analyses) (Liberati et al., 2009).

135 **Criteria for considering studies in this review**

136 **Types of studies.** Any randomized control trial, single case or case series studies were
137 considered for inclusion. No cross-sectional studies were included in this review. Only primary
138 and original studies were considered.

139 **Types of participants.** Participants from 6 to 10 years old diagnosed with various
140 disabilities. Research with participants who were exclusively diagnosed with ASD or cerebral
141 palsy were excluded. There is a large body of research with participants with these diagnoses but
142 a lack of research with participants with other diagnoses or mixed diagnoses at these ages

143 **Types of interventions.** This review included intervention studies focused on improving
144 communication skills of children who use AAC, published between January 2000 and April
145 2018. The search was limited to the last years due to the technological advances that have
146 modified AAC system and interventions. The aim of the review was to synthesize the most
147 current evidence. **Types of outcomes.** Studies that measured child communication skills via any
148 modality were included in this review.

149 **Literature Search**

150 The following databases were electronically searched between the 20th April 2018 and
151 3rd May 2018: MEDLINE (OVID), PsycINFO (EBSCO), ERIC (ProQuest), SCIELO (WOS),
152 Teacher Reference Center (EBSCO) and Education Database (ProQuest). The following terms
153 were included in the search strategy: "Augmentative and Alternative Communication",
154 "Children", "Young", and "intervention". These concepts, their synonyms and their pertinent
155 indexed terms were conveniently combined using Booleans, truncations and other operators. All
156 the searches were conducted and adapted to the features of each database (ALR). No limitation
157 was performed in the searches. All search strategies can be seen in supplementary material 1.

158 So as to complete the electronic search and to ensure the inclusion of all existing
159 literature, reference tracking and other search methods were used in line with the
160 recommendations of Greenhalgh & Peacock (2005). Those references were included in the third

161 screening. Indeed, the reference list of all reviews, both systematic and narrative, was checked in
162 order to detect more potential studies not found in the electronic search (GRE).

163

164 **Study selection**

165 All documents indexed in two or more databases (duplicates) and those that were non-
166 informative or incorrect were removed by a reviewer (ALR) during the first screening. The only
167 documents that provided enough information to be screened were included in the selection
168 process.

169 In a second screening process two authors (ALR and NIM) independently reviewed the
170 title and abstract of all documents to identify which were potentially relevant. Finally, in the
171 third screening, the reviewers used the full text to independently determine which documents met
172 the aforementioned inclusion criteria; these were considered in the systematic review. Any
173 disagreement was resolved by consensus procedure, followed, if required, by scrutiny from a
174 third review author (GRE).

175 **Assessment of Study Quality**

176 To assess the quality of the included studies the Single-Case Experimental Design Scale
177 (SCED) was used (Tate et al. 2008), where clinical history, target behavior, design, baseline,
178 sampling behavior during treatment, raw data, inter-rater reliability, independence of the raters,
179 statistical analysis, replication and generalization categories were assessed. Two authors (ALR
180 and NIM) independently assessed the quality of each of the studies answering “yes” or “no” to
181 each of the categories in the scale. After the independent assessment of the quality, reviewers
182 compared their answers and when there was any disagreement they discussed until they reached

183 agreement and whenever that was not possible a third author (GRE) was consulted, whose
184 decision finally prevailed.

185 **Data Management and analysis**

186 Two reviewers (ALR and NIM) extracted the main characteristics and data of the
187 included studies in an *ad hoc* designed template. The characteristics extracted were study author,
188 year, country, aim of the study, participant's characteristics, study design, setting, AAC method
189 used, baseline, intervention, generalization and maintenance information, and main results of the
190 study. Each reviewer independently extracted data from the studies and the extracted data were
191 compared to ensure accuracy..Disagreements were discussed by the authors until a consensus
192 was reached When this was not possible, a third author was consulted (GRE). A descriptive
193 analysis of the extracted data was performed in this review.

194 To assess the agreement between reviewers in the screening phases and quality
195 evaluation, before a consensus between reviewers was reached, observed agreement and Cohen's
196 Kappa (Cerdeira & Villarreal, 2008) were calculated using SPSS® statistical software package
197 (version 23.0.0.1, IBM® Company, Armonk, NY, USA).

198 **Results**

199 **Study selection**

200 A total of 1,709 studies were found in the electronic search, of which 28 studies were not
201 original and 657 were duplicates. 1,204 studies were included in the second screening, of which
202 1,014 were removed (Figure 1). The observed agreement between reviewers was of 88%
203 (Cohen's kappa = 0.7). A further 74 publications were identified using other search methods
204 (Greenhalgh & Peacock, 2005). 264 studies were included in the third screening using their full

205 text. Finally, 14 studies met this systematic review's criteria and were selected. The observed
206 agreement in this phase was of 80% (Cohen's Kappa =0.5).

207 [Insert figure 1 around here]

208 **Study Quality**

209 Table 1 shows the assessment of the methodological quality of the included studies.
210 Observed agreement between reviewers was 73% and Cohen's Kappa= 0.4. Generally speaking,
211 the quality of the included studies was good. All studies except one (Harding et al., 2011)
212 properly defined children's characteristics and impairments in their clinical history. Target
213 behavior was also well defined in all studies but one (Rudd et al., 2007).

214 [Insert table 1 around here]

215 The design was appropriate to determine the effectiveness of the interventions with the
216 exception of two papers (Light et al. 2008; Soto et al., 2007). As for the baseline measurements,
217 only Stephenson (2009), Rudd et al., (2007) and Harding et al. (2011) did not perform nor
218 describe properly the baseline phase. Sampling behavior was adequately described and measured
219 in all studies but two (Light et al., 2008; Soto et al., 2007). Regarding the raw data record, all
220 studies but one (Light et al., 2008) provided raw data and graphics on baseline, intervention and
221 other study phases.

222 Intra-rater reliability was properly assessed and described in 12 studies; Light et al.
223 (2008) and Harding et al. (2011) did not carry out any reliability studies on their data. Only two
224 studies describe independence of the assessors (Lanter et al., 2016; Harding et al., 2011) and just
225 3 studies conducted any statistical analysis to test the interventions' effectiveness (Harding et al.,
226 2011; Edmister & Wegner, 2015; Rudd et al., 2007).

227 Van der Meer et al. (2012), Choi et al.,(2010), Soto et al., (2009), Truxel & O’Keefe
228 (2007), Edmister & Wegner (2015), Rudd et al., (2007), Millar et al.,(2004) replicate their
229 interventions in different situations. Finally, 5 of the 14 papers included did not conduct any
230 activity to generalize their interventions (Van der Meer et al., 2012; Stephenson, 2009; Light et
231 al., 2008; Edmister & Wegner, 2015; Harding et al., 2011).

232 **Studies’ characteristics**

233 Country of the studies

234 Nine out of the 14 studies included in this review were conducted in the USA, and two in
235 the United Kingdom. The other 3 studies were conducted in Australia, South Korea and New
236 Zealand (Table 2). Two studies reported their intervention language and native language of the
237 participants (Truxel & O’Keefe , 2007; Edmister & Wegner, 2015).

238 [Insert table 2 around here]

239 Aim of the studies

240 The aim of the studies, generally speaking, was to improve skills that help children to
241 communicate with others at different levels and ways (table 2). Specifically, there were 3 studies
242 with a aim related to writing skills (Millar et al. ,2004); Truxel & O’Keefe, (2007); Light et al.,
243 2008) evaluated the effect of a phonological awareness program as a first step of the writing
244 process.

245 An additional 3 studies focused on teach more vocabulary to help children to
246 communicate. Rudd et al. (2007) tested the effectiveness of modified sign program in the
247 numbers of sign items learned. Stephenson (2009) studied the effectiveness of a book reading
248 program to help children to relate line drawings (used as communication symbols) to picture
249 book illustrations and to the spoken word. Harding et al. (2011) tested the effect of an

250 intervention program based AAC in children's expression and comprehension but also social
251 interaction and behavior.

252 Soto et al. (2007), Soto & Dukhovny (2008), and Soto et al. (2009) tested an intervention
253 (based on book reading, personal stories...) to improve the narrative skills and vocabulary of
254 children using AAC (table 2). Choi et al. (2010), Snodgrass et al. (2013), Edmister and Wegner
255 (2015) and Lanter et al. (2016) tested the effectiveness of their interventions in taking turns and
256 making requests with AAC. In the same line, Van der Meer et al. (2012) evaluated whether
257 children made greater progress in requesting with the AAC system they showed a preference for.

258 *Study design*

259 Regarding study design, five papers employed a multiple-probe design (Millar et al.,
260 2004; Soto & Dukhovny, 2008; Soto, et al., 2009; Choi et al., 2010; Van der Meer et al., 2012)
261 and three multiple-baseline design (Truxel & O'Keefe, 2007; Snodgrass et al., 2013; Edmister &
262 Wegner, 2015) (supplementary material 2). Two studies used AB design with a follow-up phase
263 to assess generalization (Soto et al., 2007; Lanter et al., 2016), another two used ABA design
264 (Stephenson, 2009; Light et al., 2008) and finally two used a pre-test and post-test design (Rudd
265 et al., 2007; Harding et al., 2011).

266 *Setting*

267 The majority of the studies (12 of 14) were conducted in a school setting. One study was
268 conducted at a children's home and/or summer daycare facility (Edmister & Wegner, 2015) and
269 one in a university Speech, Language and Hearing Clinic (Lanter et al., 2016) (supplementary
270 material 2).

271 **Participants' characteristics**

272 In the 14 studies included in the review 40 children aged from 6 to 10 years were studied
273 (table 2). Five studies (Soto et al., 2007; Light et al., 2008; Soto & Dukhovny, 2008; Snodgrass
274 et al., 2013; Lanter et al., 2016) studied the effect of an AAC intervention on one participant, one
275 study on two participants (Harding et al., 2011), three studies with three participants (Millar et
276 al., 2004; Soto et al., 2009; Edmister & Wegner, 2015), four studies with four participants
277 (Truxel & O’Keefe, 2007; Stephenson, 2009; Choi et al., 2010; Van der Meer et al., 2012) and
278 finally one study conducted research with 8 participants (Rudd et al., 2007).

279 As for the participants’ characteristics, six were diagnosed with cerebral palsy and four
280 also with cognitive delay (table 2). There were three participants with Down’s syndrome, of
281 whom two were also diagnosed with autistic spectrum disorder or autistic-like behavior. Four
282 participants were diagnosed with autistic spectrum disorder, of whom three also had severe
283 developmental disabilities. Twelve participants had intellectual disabilities and two were
284 severely physically disabled, of whom one had visual difficulties. The other participants had
285 various different diagnoses: multiple disabilities, microcephaly, congenital myotonic dystrophy
286 and autistic-like behavior, muscular atrophy, severe developmental disabilities, verbal apraxia,
287 alternating hemiplegia, a rare genetic disorder and perisylvian syndrome.

288 **Intervention characteristics**

289 *Length, frequency and intensity*

290 The average length of the interventions was 9.5 weeks (supplementary material 2),
291 varying from five weeks (Harding et al., 2011) to 6 months (24 weeks) (Soto et al., 2009). Rudd
292 et al.’s (2007) intervention lasted 6 weeks, as did Soto et al.’s (2007) and Soto & Duchovny’s
293 (2009) research. Lanter et al. (2016) employed an intervention of 10 weeks. The rest of the
294 articles did not define the duration of their interventions.

295 The average frequency of the sessions was 2.8 sessions per week (supplementary material
296 2). 5 sessions per week (Harding et al., 2011) was the highest frequency and 2 sessions per week
297 was the lowest and most repeated frequency (Rudd et al., 2007; Light et al., 2008; Soto et al.,
298 2009; Lanter et al., 2016).

299 All the studies included in this systematic review used aided AAC systems, 5 of which
300 also used an unaided system in their interventions. Eight of the studies used high-tech AAC
301 systems, four low-tech and two studies combined low- and high-tech systems (supplementary
302 material 2).

303 In one study the researchers were required to simplify their intervention for one of their
304 participants (Millar et al., 2004), because the participant did not reach the minimum assessment
305 to get on the next phase of the study.

306 *Interventions description*

307 The intervention focused on vocabulary gains (Rudd et al., 2007; Stephenson, 2009)
308 Harding et al., 2011) combined real objects, drawings, illustration and/or sings to teach new
309 words to children. Stephenson (2009) used a book or storytelling as a tool in their interventions.

310 As for studies with narrative aims, Soto et al. (2007) and Soto & Dukhovny (2008), used
311 a book or storytelling as a tool in their interventions. Soto et al. (2007) also introduce a
312 generation of a personal and a fictional story. Soto et al. (2009) used a photo to generate a
313 personal story description, and a description of personal state (table 2).

314 The 4 studies focused on requesting (Choi et al. ,2010; Van der Meer et al., 2012;
315 Snodgrass et al., 2013; Edmister & Wegner, 2015); Lanter et al., 2016), interventions were based
316 on giving the participant an stimuli (e.g.: question, making an offer of something...)

317

318 **Outcomes characteristics**

319 Various outcomes were measured in the studies with the general aim to teach more
320 vocabulary to communicate. Rudd et al. (2007) accounted the number of correct items modified
321 sign item performed. Stephenson, 2009 the correct number of matches between words, line
322 drawings, book illustration and real objects. Harding et al. 2011 measured objects of reference,
323 gestures and signs used, and also used Pragmatics Profile of Everyday Communication Skills
324 tool to assess expression, comprehension, social interaction and behavior (table 2). In those
325 studies in which the aim was to improve narrative skills, linguistic complexity and story
326 complexity was measured in 3 studies (Soto et al., 2007, Soto & Dukhovny, 2008), and Soto et
327 al., 2009). Linguistic Complexity was usually measured by number of different words (NDW),
328 number of total words (NTW), the number of clauses, and the variety of morpho-syntactic
329 structures (table 2). Soto et al., 2009 measured also Narrative Assessment Profile through topic
330 maintenance, event sequencing, explicitness, referencing, conjunctive cohesion, and fluency of
331 the children in their narratives.

332 Choi et al. (2010), Van der Meer et al (2012), Snodgrass et al. (2013), Edmister &
333 Wegner (2015) and Lanter et al. (2016) measured the number of correct request, rejection or
334 turns taken by their participants to measure intervention effect (table 2).

335 The studies phonological awareness as first step for writing, letter-sound correspondence
336 was measured (Millar et al., 2004; Truxel & O'Keefe, 2007 and Light et al., 2008). Truxel &
337 O'Keefe (2007) measured also word recognition and spelling abilities, and Light et al., (2008)
338 single word reading, simple sentences reading, typing short sentences.

339 **Studies' Results**

340 All studies found that their intervention was effective except one, the Edmister & Wegner
341 (2015) study, which found that their intervention was effective in the first phase of the study but
342 not on subsequent.

343 Children that participated in Rudd et al. (2007), Stephenson (2009) and Harding et al.
344 (2011) studies, learned to use more sign items, related more signs or illustrations (pictograms).
345 Studies of Choi et al. (2010), Van der Meer et al (2012), Snodgrass et al. (2013), Edmister &
346 Wegner (2015) and Lanter et al. (2016) also have a positive results, increasing the correct
347 number of requesting, rejection or turns taken to communicate (table 2). In the case of Van der
348 Meer et al (2012) gains were higher when the AAC system was the “favorite” for the user.

349 Intervention focused on phonological awareness (Millar et al., 2004; Truxel & O’Keefe,
350 2007 and Light et al., 2008) improved the number of letters recognized by children. Truxel &
351 O’Keefe (2007) also showed advances at various levels in phone awareness and three children
352 increased their spelling abilities. In the case of Light et al. (2008), the participant was able to
353 participate actively in reading activities and type simple sentences (table 2).

354 In studies with more than one participant it was common to find different degrees of
355 skills acquisition among each participant. Truxel & O’Keefe’s (2007) study found one child
356 reached the predefined criterion, three children maintained their skills and one generalized, using
357 untaught letter sounds. Stephenson (2009) found that all children improved their understanding
358 of the relationship between graphic symbols, illustrations and objects, and these results were
359 particularly noticeably in one child. In Harding et al. (2011) one children increased his/her
360 communication prompts in all settings and the other only during lunch-time.

361 **Discussion**

362 This systematic review identified 14 studies that assessed the effectiveness of AAC based
363 interventions on communication skills on children from 6 to 10 years old with mixed diagnoses.
364 The analyses carried out showed that these interventions were focused on improving narrative
365 skills, vocabulary, requesting or improving phonological awareness, and overall they were
366 effective. Methodological quality analysis showed that the study quality was good, two main
367 drawbacks were the lack of statistical analysis and the blinding of study phases to coders

368 *Interventions*

369 One of the most important conclusions that can be drawn from this research is that
370 students with significant physical and developmental disabilities who use aided or unaided AAC
371 systems seem to benefit from receiving evidence-based interventions that go beyond early
372 childhood (Millar et al., 2006) that may help in their integration. In particular, writing skills,
373 which are generally acquired in elementary school, could be also taught to children with CNN
374 using phonological awareness interventions. This kind of programs has demonstrated to be
375 effective in teaching letter-sound correspondence effectively (table 2), and even spelling (Truxel
376 & O'Keefe, 2007) or write simple words properly (Light et al., 2008).

377 Programs focused on improving requesting (rejecting, taking turns), focused on
378 vocabulary gains or narrative skills would be also very helpful at this age in which children tend
379 to attend school and when socialization development is very important (Rogers, 2000).

380 However, of all the studies, those working on narrative skills might be of special interest
381 since they are connected with the development of memory, personal identity and social
382 connections (Soto, et al., 2009). These are factors of indisputable importance for the self-
383 development of school-aged children (Pfeifer & Peake, 2012).

384 Therefore, professionals working in schools should be aware of the different options for
385 AAC interventions and adapt them to children needs and educational context. In order to ensure
386 the acquisition and maintenance processes, individual user's unique abilities, needs, and their
387 preferences are allowed for (Van der Meer et al., 2012), different AAC options should be
388 considered and evaluated. It is also recommended that professionals monitor AAC systems
389 across major transitions for all children, so that what was previously gained is not lost
390 (Snodgrass et al., 2013).

391 Another interesting point is that all the interventions analyzed were carried out with aided
392 AAC methods. Therefore, with this review the current lack of research into the effects of aided
393 AAC methods with 6 to 10 year old children can be responded (Millar et al., 2006). In fact, this
394 review emphasizes the use of high-tech AAC methods (10 of the 14 studies used this type of
395 intervention, alone or in combination). Moreover Van der Meer et al. (2012) found that users
396 may learn high-tech AAC options more rapidly because they are easier to teach. Besides, today's
397 children, in the countries undertaking this research, are almost all digital natives and that,
398 although still expensive, access to technological devices is becoming easier (Banda & Alzrayer,
399 2018), high-tech AAC systems should be essential future options for professionals.

400 As far as the participants in the study are concerned, it is worth highlighting the wide
401 range of diagnoses. This reinforces the option of using AAC with different children (Lynch et
402 al.,2018), which should be taken into account by clinical and educational professionals when
403 adapting methods to each diagnostic context. However, the fact that the characteristics of study
404 participants have been so varied and that the number of participants in each study is limited
405 (most studies had fewer than four participants) makes it more difficult to generalize specific
406 factors that can predict the effectiveness of AAC methods and interventions.

407 Moreover, AAC is a widespread method for people with communication impairments,
408 however it is remarkable that all the reviewed studies except one were carried out in English-
409 speaking countries (USA, UK, Ireland, New Zealand, Australia). Even though the method is used
410 in many other countries (Boillos et al., 2019; Choi et al., 2010; Zangari et al.,1994), there is few
411 research on the effectiveness AAC methods and interventions in other languages than English. It
412 is necessary to implement research on AAC methods and interventions in other languages,
413 countries and cultures. To accomplish successful AAC interventions the spoken receptive
414 language should be taken into consideration, especially if access to more complex expressive
415 grammar is desired (Tönsinga et al.,2018). Different languages may need different vocabularies,
416 different visual layout options, and different methods of representation (Baker & Chang, 2006;
417 Yong, 2006). Therefore, it would be interesting to contrast these results with those from
418 participants in countries with other languages, bilingual backgrounds (Wagner, 2018) or even in
419 multilingual countries (Tönsinga et al., 2018).

420 *Strength and limitations*

421 This systematic review is, to our knowledge, the first that has studied the effectiveness of
422 AAC based interventions in children from 6 to 10 years old with mixed diagnoses. This research
423 has used a rigorous methodology and has been performed and described following the
424 recommendations of experts in the field (Higgins & Green, 2011; Liberati et al., 2009). The
425 literature searches were extensively conducted in the six major databases in the areas of
426 education and medicine. Two specifically trained independent reviewers performed the study
427 selection, quality assessment & data extraction.

428 Nevertheless, this systematic review has also some weaknesses. Overall the observed
429 agreement was very good (from 70%-88%), however Cohen's Kappa, an index that takes into

430 account the possibility of the agreement occurring by chance (Cerde & Villarroel , 2008), was
431 from good to moderate. Moreover, the data extraction was no coded and no inter-rater agreement
432 calculation was made. Other drawback of this study is that no meta-analysis and no precise
433 conclusion could be draw due to the heterogeneity of the interventions and participants

434

435 *Further investigations*

436 Taking into account the vast literature search performed in this review, 14 research on
437 children from 6 to 10 with mixed diagnosis might not be enough. More research in this specific
438 age, which have specific, needs related to schooling and socialization process should be
439 conducted. These investigations should focus on more standardized interventions (e.g. length,
440 frequency, content) and outcomes in order to ease comparison between studies and systematic
441 reviews. Otherwise, it would be impossible to determine which is legitimately the best
442 intervention to each target population.

443 On the other hand, it would be also interesting to study the effects of interventions in
444 non-English languages and take into account and report the native language of the participants
445 and whether they are multilingual or not. Whilst all the evidence found so far is on AAC
446 interventions in English, there is a lack of evidence for other languages. It ia a reality that that
447 AAC interventions are being performed in many different countries, but there is no scientific
448 research on their effectiveness.

449 Regarding methodology, it should be suggested to researchers to follow the
450 recommendations of Tate et al. (2008) on study design. It is underlinable that in the light of
451 results on the quality assessment, assessors must be blinded to all study phases and the
452 intervention administrator must be uninformed about the measurements results as far as this is

453 possible This lack of independence is quite usual in single case studies (15%) (Tate et al., 2008),
454 but it would be ideal to improve research in this aspects to ensure the independence of the
455 assessors, to reduce bias and improve the evidence in single case studies. Additionally, only
456 some of the studies performed replication and generalization of the interventions (50% and
457 63.4%). Indeed, researchers should also include replication and generalization of their
458 interventions as these are essential to understanding their effects.

459 Besides, authors should perform a statistical analysis on the raw data to determine the
460 size effect of their interventions. Visual analysis is an appropriate method to determine whether
461 there is change between baseline, intervention and maintenance phases (Tate et al., 2008) and is
462 a very important and relevant analysis in this type of study design. However, in line with experts
463 in single case studies (Tate et al., 2008; Tate et al., 2013; Byiers et al., 2012) statistical analysis
464 should also be performed to test more objectively the interventions' effects and accompany the
465 visual analysis.

466 It would be also recommendable to authors of single case study articles to follow Single-
467 Case Reporting Guideline In Behavioral Interventions (SCRIBE) guidelines (Tate et al. 2016) to
468 report their research and improve the quality of papers in this research area. This might also ease
469 the quality assessment of the studies and evidence gathering methodology through systematic
470 reviews.

471 *Practical implications*

472 Professionals who work with children with CCN from 6 to 10 years old should take into
473 account the characteristic of the interventions of the studies included taking into account the
474 purpose of their interventions (e.g.: request, narrative skills...). In addition, the outcome and the
475 methods to evaluate them should be consider to track the progress of the children.

476 In this line professionals should embrace Evidence-Based Practice (EBP) principles to
477 design interventions for children with CCN as AAC itself involves a wide range of techniques,
478 strategies and technologies to support complex communication needs (Cook & Polgar, 2015).
479 Therefore, a professional working with children with CCN has to make a vast number of
480 decisions to design an effective AAC intervention. In this regard EBP emphasizes the importance
481 of integrating research evidence into the decision-making process (Schlosser & Raghavendra,
482 2004) along with their professional expertise and user's values and preferences. In order to make
483 a decision based on EBP three aspects need to be taken into account: 1) Current high-quality
484 research evidence, 2) Professional expertise and 3) A user's characteristics, values and
485 preferences. In regards to AAC systems, the choice of system should take into account the
486 child's preferences as it has been proved that doing so has a positive effect on the acquisition,
487 maintenance and generalization of their AAC system user skills (Van der Meer et al., 2012).

488 **Conclusions**

489 In this research 14 studies analyzed the effects of AAC interventions in children
490 communication skills from 6 to 10 years old with mixed diagnoses being all the studies except
491 one conducted in English speaking countries. The interventions were focused on phonological
492 awareness, vocabulary, requesting and developing narrative skills being interventions and
493 outcomes very heterogeneous. For this reason it is hard to decide what is the best method and the
494 best intervention for each target participant in spite of the positive effect of all the interventions. .
495 It seems that the acquisition of skills using an AAC method is also better when the child prefers
496 the method. The study quality was overall good even though the majority of the studies did not
497 blind the professionals involved to the study phases and assessment results and no statistical

498 analysis was conducted. In the same vein, around half of the studies did not perform replication

499 and/or maintenance phases.

500

501

502

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Figure 1. Flow chart of the studies selection process.

Supplementary material 1: Electronic Search Strategies.

Supplementary material 2: Characteristics of the interventions