Education and Training in Autism and Developmental Disabilities, 2020, 55(2), 119–141

Studies Comparing Augmentative and Alternative Communication Systems (AAC) Applications for Individuals with Autism Spectrum Disorder: A Systematic Review and Meta-Analysis

Orhan Aydin and Ibrahim H. Diken
Anadolu University

Abstract: In the present study, we aimed to make an evaluation, conduct comprehensive descriptive analyses, and calculate the effect sizes of studies which compare AAC applications designed according to single-subject research designs and conducted for individuals with ASD. Within the scope of this aim, 21 studies meeting the inclusion criteria were determined among the studies obtained by the systematic review. Firstly, the descriptive analysis of the included studies was conducted, and then they were evaluated in terms of the "Quality Indicators of Single-Subject Experimental Research Studies" and "acceptability" criteria suggested by Horner et al. (2005). The improvement rate difference effect sizes of 11 studies that were assessed as "acceptable" were calculated, and they were evaluated according to the design standards of the What Works Clearinghouse (WWC, 2017). The obtained findings were discussed in the light of the literature, and various suggestions were presented for future studies and practices.

Autism spectrum disorder is a neuro-developmental disorder of which estimated prevalence has increased significantly in the last 20 years (Rice et al., 2012). The prevalence, which was 4–5 per 10000 in the early 1990s, is stated to be 1 per 68 according to the data for 2010 (Centers for Disease Control and Prevention-CDC, 2014), and 1 per 59 according to the data for 2014 (Baio et al., 2018). Nowadays, the increasing number of individuals diagnosed with ASD has led to an increase in the number of researchers working on the education of these individuals. Researchers conduct studies on various skills such as communication skills of these children, academic skills, independent living and reducing problem behaviors (e.g. Boyd et al., 2015; Caroll & Kodak, 2014; Fletcher-Watson et al., 2016; O'Malley et al., 2014; Schmidt et al., 2014).

The majority of individuals with ASD draw attention with their deficiencies in communication skills, which are an important criterion in the diagnostic criteria included in the fifth edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5; APA, 2013). In the literature, it is stated that approximately 50% of these individuals cannot speak fluently (Hart & Banda, 2009). Furthermore, among individuals with ASD who attend a program in an educational environment, between 25% and 61% have very little communication skills or do not have functional communication skills (Schlosser & Wendt, 2008). However, in the literature, there are different applications to increase communication skills of these individuals. Among these applications, augmentative and alternative communication systems (AAC) are used by many researchers and practitioners to increase communication skills of individuals with ASD (Ganz et al., 2012). AAC applications are temporary or continuous practices aimed at eliminating or supporting deficiencies in the language, speech, and communication skills of individuals (Vento-Wilson, 2014). AAC applications are generally classified in two ways as aided and unaided. While unaided applications are the applications in which an individual communicates by

Correspondence concerning this article should be addressed to Orhan AYDIN, Research Institute for Individuals with Disabilities, Anadolu University, Eskisehir, 26210, TURKEY. E-mail: o_aydin@anadolu.edu.tr

using his/her own body (e.g. manual sign, gestures, and mimics), aided applications are the applications in which an external intervention (e.g. images, words, speech-generating technological devices) is performed (Mirenda, 2003; Mueller, 2014).

Unaided AAC applications, especially manual sign, are the applications that can be used for communication. However, the fact that the listener does not know a process like a manual sign and there are not individuals who can understand and respond to the manual sign in every environment (e.g. store, restaurant) is a limitation regarding its functionality. Furthermore, the inadequacy of motor skills and the limited ability to use gestures make it challenging to learn unaided AAC applications for individuals with developmental disabilities such as ASD (Lorah et al., 2015; Mirenda, 2003). Aided AAC applications include a variety of applications such as Picture Exchange (PE), Picture Exchange Communication Systems (PECS), Speech Generating Devices (SGD) or Voice Output Communication Aids (VOCA), high-tech speech generating device applications running on iPad or tablet (e.g. Proloquo2go, MyTalk; Mueller, 2014; Shane et al., 2012).

Aided AAC applications are practices that can be used to increase some academic skills of individuals with ASD, especially communication skills, and to reduce their behavioral problems. Among these applications, PECS, which include picture-based communication processes, were developed by Bondy and Frost (1994). In this application, the child exchanges the desired object with the picture by giving the picture of the object that he/she desires to the person with whom he/she communicates. The PECS is an advantageous application because it requires fewer motor skills. In a study conducted by Tincani (2004), it was found out that the PECS was more effective than the manual sign practice in communication skills of a child who had inadequate motor skills. Furthermore, PECS practices are less costly than SGD applications. Besides these advantages, it is considered a disadvantage that these practices do not include an educational process related to speech output (Boesch et al., 2013a). SGD applications are portable technological devices that contain symbols that can express a word or sentence and that can provide digital or artificial sound output. SGD applications are durable, in contrast to PECS in which the used materials are damaged over time. They are practices that are simple to use and focus more on sound output (Boesch et al., 2013a). Because of these characteristics, it is stated that the SGD aplications are more preferred by individuals with ASD (e.g. Achmadi et al., 2014; Couper et al., 2014; Lorah, 2016). Besides these benefits, they are more expensive (Boesch et al., 2013a, Lorah et al., 2015), and they are heavy and bulky in terms of portability, especially for individuals with ASD who have a physical disability (Boesch et al., 2013a).

A large number of studies have been carried out in the literature on aided and unaided AAC applications. In addition, review and meta-analysis studies have been conducted in order to evaluate what kind of application is more effective in teaching what kind of skills in individuals with ASD. For example, in the review and meta-analysis study conducted by Schlosser and Wendt (2008), 11 studies, nine of which were single-subject and two of which were experimental, were evaluated. While six of the studies were PECS practices, three of them were on SGD. Furthermore, both PECS and manual sign were applied in one study. One study includes only unaided AAC applications. As a result of their analysis, the researchers concluded that AAC applications did not prevent individuals with ASD from generating speech, on the contrary, these applications supported speech generation.

In the meta-analysis study conducted by Ganz et al. (2012), 24 studies designed according to the single-subject research design, in which aided AAC applications were applied, were reviewed. While 16 of these studies were picture-based or PECS applications, eight of them were applications related to SGD. According to the results of the Improvement Rate Difference (IRD) effect size (84% CI), it is stated that aided AAC applications are effective applications on the target behavioral outcomes of individuals with ASD. Moreover, although aided AAC applications also affect other skills (e.g. academic skills, reduction of problem behaviors), it has been reported that

they have an effect especially on communication skills of individuals with ASD.

In a systematic review study conducted by Logan et al. (2017), 30 studies consisting of 24 single-subject and six group experimental studies, in which aided AAC applications were performed to increase the social communication skills of individuals with ASD, were evaluated. Furthermore, the researchers examined applications in terms of immediate effect, and also generalization, maintenance, and social validity. Of the studies carried out, 17 were studies based on the picture (photograph) or PECS. 12 of the studies were applications with SGD in which devices such as iPad and iPod could also be used. One of the studies was the JASPER application developed and implemented by Kasari et al. (2014). Although the findings demonstrated that aided AAC applications increase the social interaction skills of individuals with ASD, it was concluded that in most of the studies generalization, maintenance, and social validity data were not considered. Therefore, it was suggested to focus on the long-term effects and generalizability of aided AAC applications in future studies.

In the another meta-analysis study conducted by Muharib and Alzrayer (2017), high-tech SGD applications aimed at individuals with ASD were analyzed. 20 single-subject studies (95% confidence interval), carried out by using tools and applications such as GoTalk, Proloquo2Go, iPad, iPod as high-tech applications, were analyzed by calculating the IRD. The findings demonstrated that high-tech applications are practices that have a significant impact on the teaching of the skills of requesting, intraverbal and multistep tacting to children with ASD. At the same time, the studies were evaluated according to the quality indicators proposed by Horner et al. (2005), and it was stated that high technology SGD applications had a moderate effect.

There is no specific meta-analysis and systematic review of the studies conducted for the purpose of reviewing comparative AAC applications. In the literature, there is a need for a systematic review of these studies because of the presence of a significant number of these comparative applications and the fact that most of them are conducted according to single-subject research designs. In the present research, we aimed to review studies of comparative AAC applications with single subject research designs for individuals with ASD. Therefore, in the light of the obtained findings, it was aimed to determine which AAC applications could be used effectively in the teaching of social communication or other skills. Furthermore, we aimed to evaluate studies in terms of quality indicators and design standards and calculate effect sizes of them. Within the scope of these purposes, we aimed to (a) perform descriptive analyses of all studies included, (b) evaluate them in terms of the "Quality Indicators of Single-Subject Experimental Research Studies" and "acceptability" criteria suggested by Horner et al. (2005), (c) calculate to effect size of studies which were assessed as "acceptable" and evaulate according to What Works Clearinghouse (WWC, 2017) design standards of them. In this study, it was preferred to use the quality indicators proposed by Horner et al. since these indicators are more comprehensive than other rubrics (e.g. treatment fidelity, participant characteristics are not a criterion in the WWC). However, Horner et al. do not consider single-subject research designs in terms of graphical quality. On the contrary, graphical quality is examined in the WWC design standards. Therefore, the relevant part in the WWC was used for investigating graphical quality in this study.

Method

Search Procedure

To access studies, Academic Search Complete, ERIC, MEDLINE, PsycARTICLE, Science Citation Index, ScienceDirect, and Scopus databases were reviewed. We involved in studies which were carried out with individuals with ASD and which were published in the English language in international peer-reviewed journals between January 1980 and November 2017. The review was started from 1980, since, in a separate diagnostic category, ASD appeared in the DSM-3 (APA, 1980), which was first published in 1980. In the process of reviewing the electronic databases, the terms *"autism, Asperger Syndrome, Autism Spectrum Disorder, PDD-NOS"* were used in relation to the term of ASD. In relation to AAC applications, the words *"functional communication, picture ex-*

change communication system, PECS, picture exchange, manual sign, augmentative communication, alternative communication, communication systems, communication aids, augmentative and alternative communication, AAC, speech generating device, voice output communication aid" were used. As a result of the review, 177 studies that were considered to be related to AAC applications were downloaded to the computer and filed in electronic format. Moreover, two additional studies were also filed in the computer by examining the references of the studies which met the comparative study criteria. Moreover, the citation lists of the studies which met the comparative study criteria were accessed by using the Google Scholar search engine, the headings of the studies on these lists were examined, and their abstract sections were reviewed if required, and ultimately two additional studies were filed by being downloaded. Thus, a total of 181 studies were filed.

Inclusion/Exclusion Criteria

In this analysis study, the inclusion criteria were determined as follows: (a) being published in the English language in international peer-reviewed journals between 1980 (January) and 2017 (November), (b) having at least one of the participants diagnosed with ASD (autism, Asperger syndrome, pervasive developmental disorder), (c) comparing AAC applications, and (d) being designed according to single-subject research designs. The exclusion criteria were determined as follows: (a) using a research design other than single-subject research designs, (b) studying different disability groups other than individuals with ASD, (c) being literature reviews, (d) not comparing AAC applications, and (e) being studies that do not provide appropriate data for visual analysis. Among the obtained 177 studies, group experimental studies (n = 19), unrelated studies not including the AAC application process (n = 18), case studies (n = 14), systematic review and meta-analysis studies related to ASD and other forms of disability (n = 12), master's theses or doctoral dissertations (n = 6), AAC applications conducted for individuals without ASD (n = 4), quantitative studies (n = 4), design-based studies (n = 3), informative studies on AAC applications (n = 3), mixed design studies (n = 2), descriptive studies (n = 2), longitudinal study (n = 1) and predictive study (n = 1) were excluded from the research. Among the obtained studies, single-subject research designs (n = 88) were reviewed again, and it was determined that there were a total of 22 comparative studies. The reference lists and Google Scholar citation lists of comparative studies were reviewed, and four studies were added. Therefore, the sum of comparative studies became 26. One of these studies (Hill & Flores, 2014) was eliminated since it did not provide appropriate data for visual analysis, and another one (Soto et al., 1993) was eliminated since it was carried out for individuals without ASD. Moreover, two studies (Scholosser et al., 2007; Trembath et al., 2009) were eliminated since they were comparative studies using other methods/applications instead of the AAC application, and another study (Ganz et al., 2014) was eliminated because it did not contain an educational process related to AAC applications and aimed to determine the frequency of use of two different AAC applications. The remaining 21 studies were filed to be included in the advanced analysis processes, by the consensus of the researchers. The flow of the processes within the scope of the search procedure and the inclusion/exclusion criteria are presented in Figure 1.

Analysis Process

All of the included studies were first analyzed descriptively, and they were evaluated in terms of the *"Quality Indicators of Single-Subject Experimental Research Studies"* suggested by Horner et al. in 2005. Then, concerning the quality indicators, the *"acceptable"* studies were determined. The meta-analyses of the studies assessed as *"acceptable"* were conducted, and they were also evaluated regarding the WWC (2017) design standards.

Descriptive Analysis. In the descriptive analysis process, the studies were coded in terms of the variables of the number of participants, age, gender, diagnosis, and intelligence quotient (IQ). The studies were coded in terms of the variables of the setting in which studies were conducted, the instructional arrangement, the design of the research, the depen-

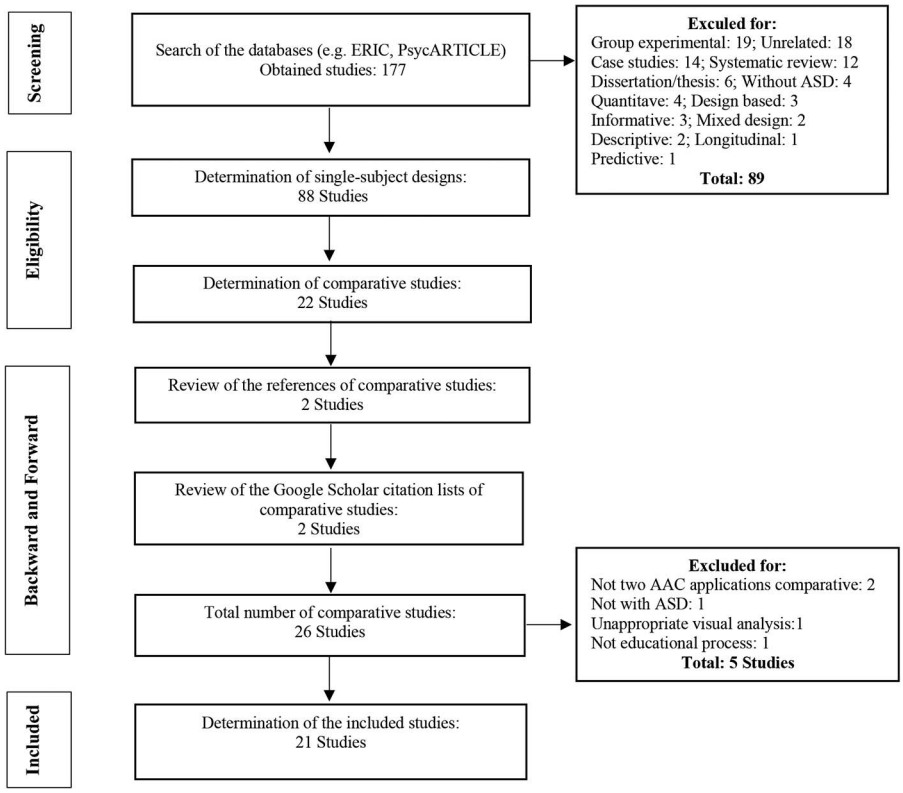

Figure 1. The evaluation of studies within the scope of the search process and inclusion/exclusion criteria.

dent variable, the compared AAC applications, the other contents used in the application process (e.g. least to most prompting, discrete trials teaching, etc.), the preferred application, the practitioner information, generalization, maintenance and social validity, interobserver agreement for the dependent variable, and treatment fidelity with regard to the practice process.

Quality Indicators. In a single-subject research, Horner et al. (2005) mentioned a total of 21 quality indicators in five categories as to be (a) description of participants and the setting, (b) dependent variable, (c) independent variable, (d) baseline, and (e) validity (internal, external and social validity). Since a study is evaulated as an *"acceptable"* study in terms of the *"Quality Indicators of Single-Subject Experimental Research Studies"* developed by Horner et al. (2005), information should be given about the listed five characteristics in that study: (a) operational definition of the application, (b) functional definition of findings, (c) treatment fidelity, (d) functional relationship between the application and the findings obtained, and (e) carrying out the experimental control with a sufficient number of studies, researchers, and participants. There is no consensus in the literature on which one of these quality indicators that are coded according to these assessment criteria will be considered. In this study, six quality indicators (see; Table 2 items) were taken into consideration including: for *"(a) the operational definition of the application"* among quality indicators item 9, for *"(b) the functional definition of findings"* items 14 and 15, for *"(c) treatment fidelity"* item 11, for *"(d) the functional relationship between the application and the findings obtained"* item 16, and for *"(e) carrying out the experimental control with a sufficient number of studies, researchers, and participants"* item 17. Which items to take into consideration from the quality indicators (Table 2) regarding the first four characteristics (a, b, c and d) we decided in accordance with the recommendations of Horner et al. as in

the work of Aydın et al. (2019). However, with regard to the statement *"carrying out the experimental control with a sufficient number of studies, researchers, and participants"*, Horner et al. (2005) mentioned that *"at least five studies should be carried out with regard to the application, studies should be conducted in at least three different regions by three different research groups, and they should be carried out with at least 20 participants."* As the studies were not based on a single independent variable, we accepted to evaluate them in accordance with item 17 by deciding that it was appropriate to evaluate this feature in itself of the studies (see, Table 2; *: Indicators that are considered as the "acceptability" criteria).

WWC Design Standards. The WWC (2017) seeks the following criteria in the design standards of single-subject research: (a) For reversal/withdrawal (AB) designs, at least four phases must be designed per case, and there must be at least five data points per phase to be rated *"meet the WWC design standards."* In case of presenting at least three data in each phase, it is rated *"meet design standards with reservations."* In case of presenting less than three data, graphical data do not meet the WWC design standards. (b) For multiple baseline and multiple probe designs, there must be at least six phases in total and at least five data points in each phase to be rated *"meet the WWC design standards."* In case of the presentation of at least three data in each phase, it is rated *"meet design standards with reservations"*. Graphical data do not meet the WWC design standards if less than three data are presented in one of the phases. (c) For alternating treatment designs, there must be at least five times (e.g. BCBCBCBCBC) comparative data for per condition in each phase and there should be a comparison of maximum two applications in each phase to be rated *"meet the WWC design standards"*. In case of the presentation of comparative data four times for per condition, it is rated *"meet design standards with reservations."* In the case of a comparison of more than two applications, a comparison of each application with each other should be made separately (e.g. comparison of A and B, comparison of A and C, comparison of C and B). If there is a comparison of more than two conditions in the same phase, it does not meet the WWC design standards. In this study, the comparative studies (mostly alternating treatment designs) that are considered as *"acceptable"* by Horner et al. (2005) were evaluated in terms of the WWC design standards.

Data Extraction. We saved screenshots of the graphs in the studies on the computer for the effect size calculation. Then, we transferred them to the GraphClick software program to digitize data. GraphClick is a software program with high accuracy and reliability in digitizing graphical data (Boyle et al., 2013; Rakap et al., 2016). We transferred graphical data to Windows Excel after digitizing with the GraphCilck software program, and then, we calculated the effect sizes by entering the digitized data to the related columns from the address of www.singlecaseresearch.org for the calculation of effect sizes.

Effect Size Calculation. In the study, in order to determine and compare the effectiveness of AAC applications, the effect size was calculated using the improvement rate difference (IRD) technique (Parker et al., 2009). The IRD is an analysis method adapted from the medical field and defined as the difference in the amount of progress between phases A and B (Parker et al., 2009). The IRD has many advantages such as: (a) interpreting the difference in the rate of improvement between the baseline and intervention phases appropriately, (b) being performed with a simple hand calculation, (c) being consistent with the visual analysis, (d) achieving the confidence intervals easily, (e) not seeking for prerequisites in distribution assumptions (e.g. normal distribution), and (f) being implemented to analyze complex single-subject research designs and multiple data series (Parker et al., 2009). Furthermore, considering confidence intervals is a unique guiding approach in the effect size calculation of single-subject research designs (Kratochwill et al., 2010). Besides these advantages, the IRD has a more sensitive measure in determining differences between the groups (Ganz et al., 2012). Due to this usefulness, the effect size was calculated using the IRD analysis technique in this study.

We calculated IRD scores using web-based IRD calculator at www.singlecaseresearch.org (Vannest et al., 2016). The obtained IRD values vary between 0 and 1. If the value of IRD is 0.50 or less, it is interpreted as a small or

suspect effect, if it is between 0.50–0.70, it is interpreted as a medium effect, and if it is higher than 0.70, it is interpreted as a high effect. In addition to the IRD, calculations in the 95% confidence interval were also performed to determine the level of precision of the IRD values. The confidence interval was 95% in this study because using the confidence interval of 84% was considered as a limitation in the study by Ganz et al. (2012), and they have suggested using high confidence interval levels in future meta-analysis studies. While confidence intervals close to each other mean that the calculated IRD values are more reliable and valid, wide confidence intervals mean that the validity of the IRD values is low (Parker et al., 2009). For example, when the calculated IRD value in the 95% confidence interval is (.80, .95) .90, it means that the IRD values are between the values of .80 and .95 with a probability of 95%, in other words, close ranged. When the calculated IRD value in the 95% confidence interval is (0.10, 0.62) .35, it means that the IRD values are between the values of 0.10 and 0.62 with a probability of 95%, in other words, wide ranged.

Reliability

We obtained five types of reliability data being related to, (a) descriptive analysis, (b) *"Quality Indicators of Single-Subject Experimental Research Studies",* (c) data extraction with GraphClick, (d) effect size of the improvement rate difference, and (e) confidence interval calculation processes. In this context, in the first stage, 33.3% of the studies ($n = 7$) were determined to be random, and for the first two reliability analyses (a and b), these studies were used. Then, 36.3% of the studies evaluated as *"acceptable"* ($n = 4$) were determined to be random, and for the last three reliability analyses (c, d, and e), these studies were used. The reliability analysis was carried out by an independent researcher, who is experienced in the mentioned processes, over the studies which were determined to be random. In the coding for these mentioned processes, consistency between coders was calculated. Therefore, the reliability data between coders were obtained by dividing the number of variables (such as indicators, numerical values of data points, evaluation points) in which an agreement was provided by the total number of variables with agreement and disagreement, and then by multiplying the result by 100. Reliability data between coders were obtained to be 94% (range: 87%–100%) for descriptive analysis, 96% (86%–100%) for quality indicators, and 100% for data extraction with the GraphClick software program, improvement rate difference, and confidence interval calculations. The coders came together and discussed the variables they could not match and reached a common decision.

Results

Results of Descriptive Analysis

The coding results of the studies ($n = 21$) regarding the related variables (e.g. dependent variable, research design) are presented in Table 1. The studies were carried out with a total of 69 children/adolescents with ASD (individuals with autism, pervasive developmental disorder or childhood disintegrative disorder). In 20 of the studies, information was provided about the gender of 60 participants, and 49 of them were male, and 11 of them were female. In the studies, which presented information about the age of participants ($n = 20$), while there were 31 participants aged between 3–6 years (pre-school period), 26 participants were between the ages of 6.1–11 years (primary school period), and 9 participants were between the ages of 11.1–14 years (secondary school period). Furthermore, in a study (Beck et al., 2008), the ages of participants were not presented; instead, it was reported that all participants ($n = 3$) were in the pre-school period. Since two separate studies were published from a doctoral dissertation study and three participants in those studies (Boesch et al., 2013a, b) were the same persons, they were not counted two times.

In terms of setting in which the studies were conducted, it is seen that more than one setting could be used in a study. While in some of these studies ($n = 11$; e.g. Tincani, 2004), practices were conducted in a quiet corner of the classroom in the special education class/classroom environment, some of them ($n = 9$; e.g. Achmadi et al., 2014) were conducted in the home environment (e.g. kitchen, dining

TABLE 1

Descriptive Analysis of the Studies

Study	*Participant (Number, age, gender, diagnosis)*	*Setting/Instructional Arrangement*	*Research Design*	*Dependent Variable*	*Compared AAC Applications*	*Instructional Contents*	*Preferred Application*	*Practitioner*	*G/M/SV*	*IOA/TF*
Achmadi et al. (2014)	3/4-5-5/3 M/Autism(3)	Home environment(2), classroom environment(1)/1:1	ATD	Request	MS, PE, SGD	Discrete trial teaching, graduated guidance, progressive time delay procedure	SGD(3)	Researcher	N/Y/N	Y/Y
Agius & Vance (2016)	3/3.1-4.3-4.5/3 M/ Autism (3)	Intervention room/two practitioners together	MBD with ATD	Request	PECS, SGD with iPad	PECS protocol, error correction	SGD(3)	Researcher	N/N/Y	Y/Y
Beck et al. (2008)	3/no age all three pre-school/3 M/ Autism (2), PDD-NOS(1)	Special education class/two practitioners together	ATD	Request, vocalization/ verbalization, using PECS and VOCA	VOCA, PECS	PECS protocol	–	Researcher	Y/N/N	Y/Y
Boesch et al. (2013a)*	3/6-7-10/2 M,1 F/Autism (3)	Therapy room(2), Kitchen at home(1)/ three practitioners together	MBD with ATD	Request	SGD, PECS	PECS protocol, using prompt	–	–	N/Y/Y	Y/Y
Boesch et al. (2013b)*	3/6-7-10/2 M, 1 F/Autism (3)	Clinic(2), home environment(1)/–	MBD with ATD	Social-com., natural speech production	SGD, PECS	PECS protocol,	–	–	N/Y/N	Y/Y
Chen et al. (2016)	3/12–13-13/3 M/ ASD (3)/IQ: 53–55-62	Teaching room/–	MT-RD (ABCACB)	Request, greeting, accurately responded to questions	SGD with two different interfaces	–	–	–	N/N/N	N/N
Couper et al. (2014)	9/between 4.2–12.3/ASD(9)	In a quiet room at school(3), in the kitchen or living room at home(5), clinic(1)/1:1	ATD	Request	MS, PE, SGD	Discrete trial teaching, 10 s. time delay procedure, graduated guidance	SGD(8), None of them(1)	Therapist, child psychologist, Ph.D. student, special education teacher	N/Y/N	Y/Y
Gevarter et al. (2017)	5/3.1-4.4-4.6-6.3-8.8/3M-2F/ASD(5)	Home environment./–	ATD	Request	SGD with four different picture contents	6 s. time delay procedure, gradually increasing the prompt	–	Graduate students	N/N/N	Y/Y
Gevarter et al. (2014)	3/3.1-3.6-3.11/3M/ ASD(3)	Home environment/–	ATD	Mands	SGD with three different picture contents with iPad	6 s. time delay procedure, The least to most prompting procedure	–	Researcher, special education teacher	N/N/N	Y/Y
Lorah (2016)	5/8.11–8.5-9.9-10.5-12.7/4 M-1 F/ Autism (5)	Special education class/1:1	ATD	Mands	PE, SGD	5 s. time delay procedure, error correction	SGD(4)	Teacher, teacher assistant	N/N/Y	Y/Y

TABLE 1—(*Continued*)

Study	*Participant (Number, age, gender, diagnosis)*	*Setting/Instructional Arrangement*	*Research Design*	*Dependent Variable*	*Compared AAC Applications*	*Instructional Contents*	*Preferred Application*	*Practitioner*	*G/M/SV*	*IOA/TF*
Lorah et al. (2013)	5/3.10-4.1-4.3-5.5-5.11/5 M/Autism (5)	Special education class/–	ATD	Mands	PE, SGD with iPad	5 s. time delay procedure	SGD(4), PE(1)	Two master students One Ph.D. student	N/Y/N	Y/Y
McLay et al. (2015)	4/5.2-7-8-10.1/3 M-1 F/Autism (4)	Special education class or adjoining room/1:1	ATD	Request	MS, PE, SGD	10 s. time delay procedure	SGD(4)	Teacher assistants, speech-language pathologist, researcher	Y/Y/N	Y/Y
McLay et al. (2017)	2/5.4-10.3/2 M/ASD(2)	Therapy room/1:1	MPD with ATD	Request	MS, PE, SGD	10 s. time delay procedure, graduated guidance	SGD(2)	–	N/N/N	Y/Y
Schlosser & Blischak (2004)	4/8-9-12-12/4 M/Autism (4)	A quiet corner of the classroom/two practitioners together	ATD (adapted)	Spelling	Print, speech and print-speech SGD	Copy-Cover-Compare	SGD_{print}(4)	Two research assistants	Y/Y/Y	Y/Y
Schlosser et al. (1998)	1/10 years/M/Autism/IQ=80	School library, a quiet corner of the classroom/two practitioners together	ATD (adapted)	Spelling	Visual, auditory and visual-auditory SGD	Copy-Cover-Compare	$SGD_{audotiry}$	Teacher and teacher assistant	N/Y/Y	Y/Y
Son et al. (2006)	3/3-3.8-5.5/2 F, 1 M/Autism (2), PDD-NOS (1)	The kitchen at home/1:1	ATD	Request	VOCA, PE	The least to most prompting procedure	PE(2), VOCA(1)	Researcher	N/N/N	Y/N
Tincani (2004)	2/5.10-6.8/M-F/ASD (2)/IQ_F:54	Special education class/1:1	ATD	Mands, motor imitation and word vocalizations	MS, PECS	Progressive time delay procedure, PECS protocol, The most to least prompting procedure, model	–	–	Y/N/Y	Y/Y
van der Meer, Didden et al. (2012)	3/6-12-13/2 M, 2 F/ASD (1), PDD-NOS (1), CDD(1)	Therapy room/1:1	MPD with ATD	Request	MS, PE, SGD	Discrete trial teaching, 10 s. time delay procedure, graduated guidance	SGD(2), PE(1)	Researcher	N/Y/N	Y/Y
van der Meer, Kagohara et al. (2012)	2/7-10/2 M/Autism (2)	Special education class/1:1	MPD with ATD	Request	MS, SGD	Discrete trial teaching, 10 s. time delay procedure, graduated guidance	MS(1), SGD(1)	Graduate assistant	N/Y/N	Y/Y
van der Meer, Kagohara et al. (2013)	2/10-11/M-F/Autism (2)	Special education class (1), dining room at home(1)/1:1	ATD	Request, greeting, saying please and thanking, answering the question with yes-no	MS, PE, SGD	The least to most prompting procedure,	SGD(1), PE(1)	Mother, researcher at the beginning, then experienced practitioner	N/Y/N	Y/Y
van der Meer, Sutherland et al. (2012)	4/4-4-10-11/3M-1F/Autism (4)	The dining room at home, special education class/1:1	ATD	Request	MS, PE, SGD	Discrete trial teaching, 10 s. time delay procedure, graduated guidance	SGD(2), PE(2)	Mother, teacher assistant	N/Y/N	Y/Y

*: studies with the same participants; ATD: Alternating Treatment Design; CDD: Childhood Disintegrative Disorder; G: Generalization; IOA: Interobserver Agreement; IQ: Intelligence Quotes; M: Maintenance; MBD: Multiple Baseline Design; MPD: Multiple Probe Design; MS: Manual Sign; MT-RD: Multiple Treatment-Reversal Design; PECS: Picture Exchange Communication Systems; PDD-NOS: Pervasive Developmental Disorder Not Otherwise Specified; SGD: Speech Generating Device; SV: Social validity; TF: Treatment Fidelity; VOCA: Voice Output Communication Aid

room). Seven of the studies (e.g. van der Meer, Didden et al., 2012) were conducted in a therapy/practice/teaching room or in a quiet room, two of the studies (Boesch et al., 2013b; Couper et al., 2014) were carried out in a clinic, and one study (Scholosser et al., 1998) was conducted in the school library. In 16 studies, information about instructional arrangement was provided. The vast majority of the studies (n = 11; e.g. Son et al., 2006) were conducted as one-to-one instructional arrangement. In five studies (e.g. Schlosser & Blischak, 2004), more than one practitioner (two or three practitioners) intervened with the student in the instructional environment.

While the alternating treatment design was used in the majority of the studies (n = 12; e.g. van der Meer et al., 2012), in five studies (e.g. van der Meer, Kagohara et al., 2012), the alternating treatment design was used together with multiple probe/baseline design. Furthermore, the adaptive alternating treatment design was used in two studies (Schlosser et al., 1998; Schlosser & Blischak, 2004), the alternating treatment design was used together with the nonconcurrent multiple probe design in one study (McLay et al., 2017), and the multiple treatment with reversal design (ABCACB) was used in one study (Chen et al., 2016).

The request skill was studied in most of the studies (n = 18; e.g. Boesch et al., 2013a). While in three of the studies (e.g. Boesch et al., 2013b; van der Meer et al., 2013), interventions for social interaction (e.g. eye contact, physical orientation, etc.) and communication (e.g. greeting, answering the question, thanking, etc.) skills were conducted, in the other three studies (e.g. Beck et al., 2008), interventions aimed at speech production/vocalization were conducted, in two studies (Schlosser et al., 1998; Schlosser & Blischak, 2004), interventions for the spelling skills in the context of academic skills were conducted, and in one study (Tincani, 2004), interventions aimed at instructing imitation skills (motor imitation) were conducted. In five of the studies (e.g. Boesch et al., 2013b), interventions for more than one dependent variable were conducted.

Three applications were compared together in some of the studies when the studies were examined within the scope of the compared AAC applications (n = 10; e.g. van der Meer, Sutherland et al., 2012). While applications for manual sign, PE/PECS (Picture Exchange/Picture Exchange Communication Systems), and speech generating devices (SGD) or Voice Output Communication Aid (VOCA) were compared in seven of these studies (e.g. Achmadi et al., 2014), different modelings (e.g. print-speech-print+speech) used in SGD were compared in three of the studies (e.g. Schlosser & Blischak, 2004). In another part of the studies (n = 10; e.g. Lorah et al., 2013), two applications were compared together. In seven of these studies (e.g. Son et al., 2006), applications performed with speech generating devices (VOCA, SGD or SGD with the iPad) were compared with the PECS. In Tincani's (2004) study, manual sign and the PECS; in van der Meer, Kagohara, et al.'s (2012) study manual sign and SGD; in Chen, et al.'s (2016) study, SGD applications with two different interfaces (pie abbreviation/expansion - hierarchical relating) were compared. In one of the studies (Gevarter et al., 2017), SGD applications with four different modelings (photo image- symbol grid - hybrid – pop-up symbol grid) were compared together. In most of the studies (n = 20), various instructional contents were added to the teaching process while AAC applications were used. The time delay procedure (n = 12; e.g. McLay et al., 2015), graduated guidance (n = 6; e.g. McLay et al., 2017), the least or the most prompting procedure (n = 5; e.g. Gevarter et al., 2017), discrete-trial teaching (n = 5; e.g. Couper et al., 2014), PECS protocol (n = 5; e.g. Aguis & Vance, 2016), and practices such as prompting or being a model, error correction and reinforcement were used in the studies. Moreover, in two studies (Schlosser & Blischak, 2004; Schlosser et al., 1998), the Copy-Cover-Compare application was conducted in relation to the dependent variable (spelling skill).

Information related to the evaluation about preferences of the participants was obtained from 14 studies (e.g. Agius et al., 2016). In these studies, 35 participants (e.g. Couper et al., 2014) preferred SGD applications, seven participants (e.g. Son et al., 2006) preferred the PECS, and one participant (van der Meer, Kagohara et al., 2012)

preferred manual sign. One of the participants (Couper et al., 2014) did not prefer any application. In the preference evaluation of the comparative studies on SGD in different modelings (n = 2; Schlosser & Blischak, 2004; Schlosser et al., 1998), four participants preferred visual SGD, and one participant preferred audio SGD.

In most of the studies (n = 16; e.g. Son et al., 2006), information about practitioners was provided. The studies (n = 10; e.g. Gevarter et al., 2017) which involved more than one practitioner in an intervention constituted the majority of them, on the other hand some of them (n = 6; e.g. Aguis & Vance, 2016) conducted with a single practitioner. Most of the studies (n = 10; e.g. Achmadi et al., 2014) were conducted by researchers/research assistants. Furthermore, special education teachers or assistant teachers (n = 6; e.g. Lorah, 2016), graduate students (n = 3; e.g. Lorah et al., 2013), mothers (n = 2; van der Meer et al., 2013; van der Meer, Sutherland et al., 2012), therapist/child psychologist (Couper et al., 2014) and speech-language pathologist (McLay et al., 2015) were involved in the studies as practitioners.

In most of the studies (n = 17; e.g. Chen et al., 2016), generalization data were not collected. The studies (n = 4) in which generalization data were obtained from settings, practitioners, participants or materials. Maintenance data were obtained nearly in half of the studies (n = 12; e.g. Boesch et al., 2013a). While three studies were obtained maintenance data after criteria (Lorah et al., 2013; Scholosser & Blischak, 2004; Schlosser et al., 1998), in other studies (n = 9) the maintenance data were collected at times after two weeks to seven months. Social validity data were obtained from teachers/teacher assistants/therapists (n = 5; e.g. Lorah, 2016) and parents/caregivers (n = 3; e.g. Aguis et al., 2016). Interobserver agreement data were obtained in all studies (n = 20) except for one study (Chen et al., 2016). The reliability coefficients vary between 80% and 100%. Treatment fidelity was obtained in all studies except for two studies (Chen et al., 2016; Son et al., 2006), the treatment fidelity coefficients vary between 89% and 100%.

Results of Quality Indicators

The evaluation of the included studies in terms of quality indicators is presented in Table 2. Since Horner et al. published quality indicators at 2005, the studies were examined with respect to before and after 2005. There were three studies (Scholosser et al., 1998; Schlosser & Bischak, 2004; Tincani, 2004) published before 2005. Among these studies, no study met all of the quality indicators. However, all of these studies (n = 3) were coded as *"Y (Yes)"* in terms of the following indicators: adequate identification of participant characteristics (item 1), adequate identification of the participant selection process (item 2), all indicators in the category of the dependent and independent variable and baseline (items between 4–13), the dependent variable being socially important (item 18), and implementation of the independent variable over extended time in typical (natural) contexts/persons (item 21). While two of the studies (Schlosser & Bischak, 2004; Tincani, 2004) were coded as *"Y (Yes)"* in terms of items 14, 15, 16, and 17 in the validity category, the other study (Schlosser et al., 1998) was coded as *"N (No)"* in terms of these indicators. While items 19 and 20 among the quality indicators were coded as *"Y (Yes)"* in two studies (Schlosser et al., 1998, Tincani, 2004), in the other study (Schlosser & Bischak, 2004), they were coded as *"N (No)."* Furthermore, the indicator *"the setting was defined adequately"* (item 3) was coded as *"N (No)"* in all three studies.

The majority of the studies (n = 18) were published after 2005. There were also none of them that met all quality indicators. However, all of them were coded as *"Y (Yes)"* in terms of the following indicators: adequate identification of participant characteristics (item 1), performing repeated measurements regarding the dependent variable (item 7), being described with replicable precision regarding the independent variable, and being systematically manipulated (items 9 and 10), and socially important dependent variable (item 18). While all of the studies (n = 17) except for one study (Chen et al., 2016) were coded as *"Y (Yes)"* in terms of reporting the interobserver agreement data (item 8), all other studies (n = 16), except for two studies (Chen et al., 2016; Son et al., 2006), were coded as *"Y (Yes)"*

TABLE 2

Evaluation of the Studies in Terms of the "Quality Indicators of Single-Subject Experimental Research Studies"

Quality Indicators	*Achmadi et al. (2014)*	*Aguis and Vance (2016)*	*Beck et al. (2008)*	*Boesch et al. (2013a)*	*Boesch et al. (2013b)*	*Chen et al. (2016)*	*Couper et al. (2014)*	*Gevarter et al. (2017)*	*Gevarter et al. (2014)*	*Lorah (2016)*
Participants and Settings										
1. The participants were described adequately	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2. The selection process was described adequately	N	Y	Y	Y	N	N	Y	N	Y	Y
3. The setting was described adequately	N	Y	N	Y	N	N	N	N	N	Y
Dependent Variable										
4. Described with operational precision	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
5. Measurable	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
6. The measurement was defined with replicable precision	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
7. Repetitive measurements were made	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
8. Interobserver agreement data were reported	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
Independent variable										
9. Described with replicable precision*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
10. Systematically manipulated	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
11. Treatment fidelity was defined*	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
Baseline										
12. Phase provided evidence for the design (pattern) before the application	N	Y	N	Y	Y	Y	Y	N	N	N
13. Described with replicable precision	Y	Y	Y	Y	Y	Y	Y	N	N	N
Validity										
14. The experimental effect has three proofs/representations*	Y	Y	Y	Y	Y	Y	Y	N	N	N
15. The design controlled the threats for internal validity*	Y	Y	N	Y	Y	Y	Y	N	N	N
16. The results presented a pattern that experimental control was demonstrated*	Y	Y	Y	Y	N	Y	Y	N	N	N
17. The experimental effects were replicated, external validity was provided*	Y	Y	Y	Y	Y	Y	Y	N	N	N
18. The dependent variable is socially important	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
19. The magnitude of change in the dependent variable resulting from the application is socially important	N	Y	N	Y	N	N	N	N	N	Y
20. The independent variable is cost effective and/or practical	N	Y	N	Y	N	N	N	N	N	Y
21. The independent variable was applied over extended time in the presence of typical (natural) contexts/persons	Y	N	Y	N	N	N	Y	Y	Y	Y
Indicators that are met/total indicators	**16/21**	**20/21**	**16/21**	**20/21**	**15/21**	**11/21**	**18/21**	**11/21**	**12/21**	**15/21**

TABLE 2—(Continued)

Quality Indicators	*Lorah et al. (2013)*	*McLay et al. (2015)*	*McLay et al. (2017)*	*Schlosser & Bischak (2004)*	*Schlosser et al. (1998)*	*Son et al. (2006)*	*Tincani (2004)*	*van der M., Didden et al. (2012)*	*van der M., Kagohara et al. (2012)*	*van der M., Kagohara, et al. (2013)*	*van der M., Sutherland et al. (2012)*
Participants and Settings											
1. The participants were described adequately	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2. The selection process was described adequately	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
3. The setting was described adequately	Y	N	N	N	N	N	N	N	Y	Y	N
Dependent Variable											
4. Described with operational precision	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
5. Measurable	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
6. The measurement was defined with replicable precision	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
7. Repetitive measurements were made	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
8. Interobserver agreement data were reported	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Independent variable											
9. Described with replicable precision*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
10. Systematically manipulated	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
11. Treatment fidelity was defined*	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y
Baseline											
12. Phase provided evidence for the design (pattern) before the application	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
13. Described with replicable precision	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Validity											
14. The experimental effect has three proofs/representations*	Y	Y	N	Y	N	Y	Y	Y	Y	N	Y
15. The design controlled the threats for internal validity*	Y	Y	N	Y	N	Y	Y	Y	Y	N	Y
16. The results presented a pattern that experimental control was demonstrated*	Y	Y	N	Y	N	Y	Y	Y	Y	N	Y
17. The experimental effects were replicated, external validity was provided*	Y	Y	N	Y	N	Y	Y	Y	Y	N	Y

TABLE 2—(Continued)

Quality Indicators	*Lorah et al. (2013)*	*McLay et al. (2015)*	*McLay et al. (2017)*	*Schlosser & Bischak (2004)*	*Schlosser et al. (1998)*	*Son et al. (2006)*	*Tincani (2004)*	*van der M., Didden et al. (2012)*	*van der M., Kagohara et al. (2012)*	*van der M., Kagohara, et al. (2013)*	*van der M., Sutherland et al. (2012)*
18. The dependent variable is socially important	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
19. The magnitude of change in the dependent variable resulting from the application is socially important	N	N	N	N	Y	N	Y	N	N	N	N
20. The independent variable is cost effective and/or practical	N	N	N	N	Y	N	Y	N	N	N	N
21. The independent variable was applied over extended time in the presence of typical (natural) contexts/persons	Y	Y	N	Y	Y	Y	Y	N	Y	Y	Y
Indicators that are met/total indicators	**18/21**	**18/21**	**10/21**	**18/21**	**16/21**	**17/21**	**20/21**	**17/21**	**19/21**	**14/21**	**18/21**

in terms of defining the treatment fidelity (item 11), and all of the other studies (n = 15), except for three studies (Chen et al., 2014; Gevarter et al., 2017; Gevarter et al., 2014), were coded as *"Y (Yes)"* in terms of being defined with replicable precision regarding the baseline (item 13). Most of the studies (n = 16, e.g. Son et al., 2006) were coded as *"Y (Yes)"* in terms of items 4, 5 and 6 in the dependent variable category. Besides, most of the studies (n = 13; e.g. Aguis & Vance, 2016) were coded as *"Y (Yes)"* in terms of the adequate identification of the participant selection process (item 2). Furthermore, 12 studies (e.g. Couper et al., 2014) in terms of the indicator of phase provided evidence for the design (pattern) before the application (item 12), other 12 study groups (e.g. Gevarter et al., 2014) in terms of the indicator of implementing the independent variable over time in typical (natural) contexts/persons (item 21), and other study groups (n=12; e.g. Achmadi et al., 2014) in terms of the indicators of having three representations of the experimental effect, controlled threats related to the internal validity of the design, and repeating the effect and providing external validity (items 14, 15 and 17, respectively) were coded as *"Y (Yes)"*. 11 studies (e.g. van der Meer, Sutherland et al., 2012) were coded as *"Y (Yes)"* in terms of the indicator (item 16) of providing a pattern that experimental control is demonstrated. A small number of the studies (n = 6; e.g. McLay et al., 2017) were coded as *"Y (Yes)"* with regard to the indicator of identifying the setting adequately (item 3). However, only three studies (Aguis & Vance, 2016; Boesch et al., 2013a; Lorah, 2016) were coded as *"Y (Yes)"* in terms of the following two indicators in the validity category: "depending on the application, the size of the change in the dependent variable is socially important (item 19)" and "the independent variable is cost effective and/or practical (item 20)."

The studies were evaluated in terms of the *"acceptability"* criteria as studies published before and after 2005. According to this, items 9, 11, 14, 15, 16 and 17 among quality indicators have been considered in terms of the *"acceptability"* criteria. In this context, while two of the studies published before 2005 (Schlosser & Bischak, 2004; Tincani, 2004) were evaluated as *"acceptable"*, nine of the studies published after 2005 (e.g. Aguis & Vance, 2016; Lorah et al., 2013) were evaluated as *"acceptable"* studies. As a result, among the included studies (n = 21), 11 studies were evaluated as *"acceptable"* studies. These studies which were evaluated as *"acceptable"* were filed for inclusion in the WWC design standards and meta-analysis processes.

Results of Effect Size and WWC (2017) Design Standards

Table 3 presents the evaluation results of the studies in terms of the design standards and meta-analysis findings. In terms of the design standards, only one of the studies (Boesch et al., 2013a) meets the design standards. In four of the studies (Aguis & Vance, 2016; Lorah et al., 2013; Tincani, 2004; VanderMeer, Kagohara et al., 2012), since the criterion of having five and more data points for per condition is not met in one phase but it is met in other phases, they meet design standards with reservation. Because more than two conditions are compared in four of the studies (Couper et al., 2014; McLay et al., 2015; Schlosser & Blischak, 2004; van der Meer, Didden et al., 2012; van der Meer, Sutherland, 2012), the carryover effect of the applications cannot be controlled, and so they do not meet the WWC design standards. In one of the studies (Achmadi et al., 2004), data were obtained two or three times in all of the baseline phases, so it was evaluated as not meeting design standards.

In terms of IRD effect size calculations, eight of the studies (e.g. Achmadi et al., 2014) which were implemented with SGD are *high effect* applications in teaching skills such as request/mands and communication skills by being evaluated over .70. In one of the studies (Couper et al., 2014), the effect size of SGD application in the teaching of the request skill was calculated to be 95% CI (.47, 86) .68, and evaluated as a *medium effect* application. The IRD effect size in all of the studies (n = 9; e.g. Tincani et al., 2004) in which picture exchange-based teaching (PE/PECS) were compared with other applications (SGD, manual

TABLE 3

Evaluation of the Studies in Terms of the WWC Design Standards and 95% CI IRD Effect Size Findings

				95% CI	
Study	*Research Design*	*WWC (2017)*	*IRD (Mean)*	*Low*	*High*
Achmadi et al. (2014)	ATD	Not meet	IRD_{SGD}: 1	1.00	1.00
			IRD_{PE}: .91	.83	.91
			IRD_{MS}: .62	.47	.76
*Aguis & Vance (2016)	MBD with ATD	Meets with reservation	IRD_{SGD}: .95	.90	.95
			IRD_{PECS}: .96	.93	.96
*Boesch et al. (2013a)	MBD with ATD	Meets	IRD_{SGD}: .96	.93	.98
			IRD_{PECS}: .91	.82	.91
Couper et al. (2014)	ATD	Not meet (For three cases)	IRD_{SGD}: .68	.47	.86
			IRD_{PE}: .81	.70	.91
			IRD_{MS}: .37	.14	.63
*Lorah et al. (2013)	ATD	Meets with reservation	IRD_{SGD}: 1	1.00	1.00
			IRD_{PE}: .98	.94	.98
McLay et al. (2015)	ATD	Not meet (For three applications)	IRD_{SGD}: .86	.73	.97
			IRD_{PE}: .72	.63	.80
			IRD_{MS}: .40	.11	.63
Schlosser & Blischak (2004)	ATD	Not meet (For three applications)	IRD_{PRINT}: .78	.67	.89
			IRD_{SPEECH}: .79	.68	.89
			$IRD_{PRINT\text{-}SPE.}$: .65	.34	.89
*Tincani (2004)	ATD	Meets with reservation	IRD_{PECS}: .93	.79	.93
			IRD_{MS}: .91	.82	.97
van der Meer, Didden et al. (2012)	ATD	Not meet (For three applications)	IRD_{SGD}: .89	.81	.96
			IRD_{PE}: .97	.94	.97
			IRD_{MS}: .47	.18	.76
*van der Meer, Kagohara et al. (2012)	MPD with ATD	Meets with reservation	IRD_{SGD}: .87	.87	.87
			IRD_{MS}: .57	.57	.57
van der Meer, Sutherland et al. (2012)	ATD	Not meet (For three applications)	IRD_{SGD}: .85	.61	.98
			IRD_{PE}: .95	.87	.95
			IRD_{MS}: .70	.25	.95

*: *Acceptable studies in terms of the WWC standards*

sign) in the teaching of skills such as requesting, vocalization, motor imitation was calculated to be higher than .70, so evaluated as a *high effect*. While three of the applications (Couper et al., 2014; McLay et al., 2015; van der Meer, Didden et al., 2012) performed with manual sign were considered to have a *small effect* compared to other applications (PECS or SGD) by being evaluated under .50, three applications (Achmadi et al., 2014; van der Meer, Kagohara et al., 2012; van der Meer, Sutherland et al., 2012) were estimated to have a *medium effect size* in teaching request skills compared to other applications by calculating the IRD effect size between .50 and .70. In one of the studies (Tincani, 2004), the application of manual sign was evaluated as an application with a *high effect* by calculating the IRD effect size as 95% (.82, .97) .91.

In another study (Schlosser & Blischak, 2004), in contrast to communication skills, the device generating three different speeches (print, speech, print + speech) was compared in the teaching of the skill of spelling among academic skills. Among the compared applications, SGD print and speech applications as separately were calculated to be higher than .70, and they were evaluated as *high effect* in the teaching of the spelling skill. However, the effect size of SGD both print and speech application was calculated to be 95% CI (.34, .89) .65, and it was evaluated as *medium effect*.

Discussion

In summary, while PECS and SGD applications among AAC applications are resulted to be equally effective in teaching social communication skills, the manual sign application is not effective at the desired level. Furthermore, there are too many variables (e.g. participant characteristics, instructional content) which may change the effectiveness of AAC applications. In addition to these findings, a remarkable finding that may affect credibility in experimental processes is that most of the studies were evaluated as not meeting design standards in terms of the WWC design standards since they compared three different applications in the same phase. Although it is not recommended to calculate the effect size of studies not meeting the WWC design standards, the rubric of Horner et al. was preferred in this article, therefore the effect sizes of the studies assessed as "acceptable" were calculated. However, it was surprisingly resulted that almost half of the studies assessed as "acceptable" could not meet the WWC design standards.

A large number of participants in the studies comparing AAC applications were either in the pre-school period or in the primary school period. The reason for the fact that the participants in the studies were mostly selected from these age ranges should be a result of considering the importance of early intervention in language acquisition. Although there were studies comparing various applications in secondary school students, there was not any study comparing AAC applications in the young/adulthood period. However, in the literature, there are a limited number of studies (e.g. Kagohara et al., 2010, Lund & Troha, 2008) which examine the effectiveness of AAC applications aimed to teach such as request/mands and answering questions to individuals who are over or at the young age (e.g. 17 years) and have ASD. Nevertheless, most of adult ASD have continued limited communication skills.

When the studies were reviewed in terms of the setting in which they were conducted, we realised that the researchers mostly preferred settings in natural contexts (e.g. student's class, home environment). This situation is important according to Horner et al. in ensuring that the quality indicator, which is "*the implementation of the independent variable in typical contexts over extended time"* is met. In all of the studies except for one study (Chen et al., 2016), the alternating treatment design (with adapted in some studies or together with the multiple probe/baseline designs) was used. It can be stated that the reason for preferring mostly the alternating treatment design is that this design can be completed as soon as possible among the comparative designs, and it is the most suitable design for controlling the factors affecting internal validity. A remarkable finding is that more than two applications are compared alternately in almost half of the studies. This situation raises the issue of carryover effects related to the dependent variable depending on the applications. The situation accepted in terms of the WWC (2017) design standards is that this effect can be minimized by comparing two applications within the alternating treatment design.

The skill of request/mands is the most targeted skill among the behaviors intended to be taught to participants with AAC applications in the studies. In other review studies, which examine the effectiveness of AAC applications conducted for individuals with ASD in the literature (e.g. Ganz et al., 2011; Lorah et al., 2015; van der Meer & Rispoli, 2010), it is seen that the request skill was studied intensively individuals with ASD, and besides this skill, other skills such as social skills, academic skills, behavior problems were also studied in some studies. According to van der Meer and Rispoli (2010), it is not surprising that there is a high tendency to teach this skill in most AAC application studies conducted for these individuals, since individuals with ASD do not acquire request skills with a natural process. Furthermore, although the request is a pivotal communication skill, it may be appropriate to acquire it before teaching more complex communication skills.

In the studies, mostly manual sign, PECS or SGD applications were compared with each other in the teaching of skills such as requesting, speech production, and vocalization. Although these applications seem like a single application, various contents such as time delay procedure, graduated guidance, the least to most/the most to least prompting procedure, discrete trial teaching have been incor-

parated into applications. Therefore, it can be said that various errorless teaching methods can be used to increase the effectiveness of AAC applications and to instruct how to use them.

Mostly participants who particapeted the studies have preferred SGD applications. This is an indication that individuals with ASD are more interested in technologically based applications. At the same time, it supports the fact that there is an increasing tendency, in the literature, to technologically based applications in teaching various skills to individuals with ASD (Grynszpan et al., 2014).

Generalization and social validity data are obtained from a limited number of studies. Although this situation is expressed as a limitation in the studies, the data can not be obtained because it can make the research process more difficult since there are more than one applications in the comparative studies. In future studies comparing AAC applications, obtaining generalization and social validity data from only effective or preferred application is an issue that should be focused on by researchers because this approach can ensure both the easy planning of the process and eliminating the negative tendencies exhibited by individuals with ASD in generalization and maintenance skills. Maintenance data were obtained from half of the studies. Long-term (e.g. 5-month, 7-month) maintenance data is important to demonstrate that the long-term effects of AAC applications can be sustained.

Interobserver agreement data and treatment fidelity data were obtained in most of the studies. The mentioned data were also obtained for most of the studies in which AAC applications with different inclusion criteria were systematically reviewed. The fact that especially the treatment fidelity data were obtained in the studies is considered important regarding to meet the criterion of treatment fidelity in evaluating a study as "*acceptable"* in terms of the *"Quality Indicators of Single-Subject Experimental Research Studies."*

There was no significant difference in the analysis results regarding the quality indicators of the included studies in terms of being published before or after 2005. However, the number of studies published before 2005 was limited. Therefore, there are no findings suitable for comparison. However, it is primarily determined that the quality indicator related to defining the setting adequately was not met in most of the studies. Furthermore, due to obtaining social validity data in a limited number of studies, the indicators of *"the change in the dependent variable due to the application being socially significant"* and *"the independent variable being cost-effective or practical"* were evaluated as *"No"* in most of the studies. The studies evaluated as *"acceptable"* are about half of the included studies. In the other studies which were evaluated as not *"acceptable,"* because the items (14, 15, 16, and 17) evaluated as "acceptable" in the validity category are not met. In addition, the fact that the baseline data were not obtained caused the studies to be coded as *"No"* in terms of these indicators. The reason for this is that although obtaining baseline data is not a required condition in alternating treatment designs, it is recommended in order to see the experimental effect (Horner et al., 2005). Furthermore, not obtaining the baseline data is especially recommended for behaviors that need to be reduced.

In terms of research designs, the number of studies meeting the WWC (2017) design standards was quite few. Most of the studies did not meet the WWC design standards since more than two applications were compared within the phase. Besides, five or more data points in each phase is a rigorous criterion in the studies, and in most of the studies, five and more data points were not obtained in per phase, especially at the baseline. Therefore, the studies meeting the design standards met them with reservation, except for one study (Boesch et al., 2013a).

When AAC applications are compared regarding the IRD effect size, the most ineffective applications are the manual sign applications. This is due to the inadequacies in the motor skills of children with ASD, as well as the difficult and complex structure of the manual sign application compared to other AAC applications (Mirenda, 2003; van der Meer, Didden et al., 2012). However, the manual sign application may be a more effective application than aided AAC applications (e.g. PECS) in acquiring communication skills for individuals with ASD who have high-performance levels regarding motor skills (Tincani, 2004).

SGD and PECS applications are effective in

teaching basic communication skills (requesting, short answering, etc.) to individuals with ASD. In the teaching of communication skills to these individuals, practitioners may be recommended to prefer these applications, but it may be also recommended to consider preferences of these individuals. In the literature, it is indicated that individuals with ASD prefer SGD applications more. As recommended by Muharib and Alzrayer (2018), high-tech SGD applications such as tablets and iPads are suitable for use in classroom environments. Most of the applications conducted with the manual sign are ineffective or have a moderate effect and are not preferred. Besides, it can be stated that it is an effective and preferred application on individuals with ASD who have high motor performance levels. Therefore, it may be recommended for practitioners to obtain comprehensive information of student characteristics for determining the application. Furthermore, the studies conducted with AAC applications show that various evidence-based applications such as error correction, reinforcement, discrete trial teaching, and time delay procedure are used within the process. Therefore, it may be recommended to practitioners who will use these applications to benefit from evidence-based practices in order to make the process more efficient. In the literature, the request skill in the context of communication skills to individuals with ASD has preferred more intensively. If the fact that these individuals exhibit behavioral problems in case they are unable to express themselves is considered (Chiang, 2008; Park et al., 2012), it may be suggested that the teaching of the skill of request/mands should be preferred as a priority by practitioners.

Implications for the Future Research

In the future comparative studies, it may be suggested to design a study in such a way that maximum two AAC applications will be compared within the per condition. If more than two AAC applications are to be compared in a study, research should be designed to compare each application with each other separately (e.g. comparison of manual sign and PECS, comparison of PECS and SGD, comparison of SGD and manual sign). In a large part of the studies designed according to the alternating treatment design, the process was conducted without obtaining the baseline data. According to Horner et al. (2005), there should be a significant difference between the baseline and intervention phases in order to have evidence of the experimental effect. Therefore, there is a suspicion that this evidence has been provided in the studies, in which baseline data have not been obtained. As a result of this, the studies are evaluated negatively in terms of the *"acceptability"* criteria. Besides, in terms of the WWC design standards, it is recommended to obtain at least five data points in each phase (baseline, intervention). Therefore, it is recommended to arrange baseline phases and to obtain at least five data points for per phase in comparative studies which will be conducted in the future.

In most of the studies, characteristics of the setting are not described in such a way as to enable the repetition. In future studies, it may be suggested to increase the repeatability of studies by describing the setting characteristics comprehensively. Social validity data and generalization data were not obtained in most of the studies. However, in comparative studies, which one of the applications is more effective and efficient can be determined by taking opinions from the parents, teachers or students. Furthermore, ability of students to use the application in different settings or in the presence of different individuals is important data for the generalization of the study results. On the other hand, the impact precision of SGD applications is low. There is a need for new studies to determine which one of these applications is more effective in teaching different skills to different participants in different conditions.

In conclusion, in this descripitve and meta-analysis study, we realised that teaching the request is mostly aimed in AAC application studies conducted on individuals with ASD. However, different skills are also taught. PECS and SGD applications come to the forefront as highly effective applications. Nevertheless, a large number of individuals with ASD prefer SGD applications. In descriptive and meta-analysis studies to be conducted in the future, it may be suggested to evaluate studies by analyzing different variables (e.g. efficiency, effect sizes of other data) with different analysis techniques (e.g. the percentage of non-

overlapping data, Tau-*U*). The WWC (2017) recommends calculating the effect size of studies that meet the design standards with or without reservation. In this study, the effect size of the studies evaluated as *"acceptable"* recommended by Horner et al. (2005) was calculated since the number of the studies meeting the design standards with or without reservation was limited. In meta-analysis studies to be conducted in the future, only the effect sizes of studies which meet the design standards (with/without reservation) may be calculated.

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**Excluded Studies

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Received: 13 February 2019
Initial Acceptance: 9 April 2019
Final Acceptance: 15 May 2019