Research in Autism Spectrum Disorders 8 (2014) 1184–1199

Contents lists available at ScienceDirect

Research in Autism Spectrum Disorders

Journal homepage: http://ees.elsevier.com/RASD/default.asp

Review

Facilitating requesting skills using high-tech augmentative and alternative communication devices with individuals with autism spectrum disorders: A systematic review

Katharine Still [a,*], Ruth Anne Rehfeldt [b], Robert Whelan [c], Richard May [d], Simon Dymond [a]

[a] Department of Psychology, Swansea University, Swansea SA28PP, United Kingdom
[b] Rehabilitation Institute, Southern Illinois University, Carbondale, Mailcode 4609, Carbondale, IL 62901, United States
[c] School of Psychology, University College Dublin, Belfield, Dublin 4, Ireland
[d] School of Psychology, University of South Wales, Pontypridd CF371DL, United Kingdom

ARTICLE INFO

Article history:
Received 11 March 2014
Received in revised form 3 June 2014
Accepted 4 June 2014

Keywords:
Augmentative alternative communication devices
Requesting
High-tech
Technology
Autism

ABSTRACT

We conducted a systematic review to identify research studies that utilised high-tech devices (e.g., smartphone technology) to teach functional requesting skills to individuals under the age of 16 with a diagnosis of autism spectrum disorder (ASD). We identified 16 studies that included a total of 46 participants. Speech generating devices were the most frequently employed mode of communication, the most frequently requested items were preferred food or toys, and the maximum number of target-requesting skills taught was eight. Research has tended to utilise the multiple baseline design or a variant thereof (e.g., a multiple-probe design). Overall, the intervention results were largely positive, suggesting that high-tech devices can be successfully implemented as augmentative and alternative communication (AAC) devices for individuals with autism. Further research is needed to evaluate the claims made about high-tech AAC devices in facilitating requesting skills in children with ASD.

Contents

* Corresponding author at: Department of Psychology, Swansea University, Singleton Park, Swansea SA2 8PP, United Kingdom. Tel.: +44 1792 295081; fax: +44 1792 295679.
E-mail addresses: k.a.still@swansea.ac.uk, katharine.a.still@hotmail.com (K. Still).

http://dx.doi.org/10.1016/j.rasd.2014.06.003
1750-9467/

1. Introduction

Autism spectrum disorder (ASD) is a neurodevelopmental disorder characterised by persistent impairments in social communication and social interaction, and restricted, repetitive patterns of behaviour, interests, or activities (American Psychiatric Association, 2013). One of the impairments in social communication commonly manifests as a delay in the onset of spoken language: up to 25% of children with ASD are estimated to never fully acquire speech (Klinger, Dawson, & Renner, 2002). Children with ASD and speech delay often come to rely on the use of an augmentative and alternative communication (AAC) device as their primary mode of communication (Mirenda & Iacono, 2009). Such devices were originally intended to address the expressive communication needs of non-vocal populations who lacked manual dexterity and had significant difficulties using a keyboard or writing by hand (Shane et al., 2012). In the late-1980s and early-1990s, individuals with ASD began to use AACs (Shane et al., 2012). At present, AACs are widely used as a platform for communication for those who do eventually learn to speak (Charlop & Haymes, 1994; LeBlanc, Dillon, & Sauter, 2009) and for children with ASD and delayed language development (Mirenda & Iacono, 2009).

In AAC systems, the use of symbols or images either supplements, or substitutes, for existing speech as a method for communicating with caregivers (Murray & Goldbart, 2009; Nunes, 2008). One of the most widely used AACs is the Picture Exchange Communication System (PECS; Frost & Bondy, 2002). In the initial stages of learning to use PECS, individuals are taught to exchange small photographs or symbols with a communicative partner in order to obtain desired items or activities. These pictures are usually laminated and stored in a portable ring binder which is carried around by the user. As the learner progress through the stages of the PECS, the pictures are used for more complex interactions such as constructing sentences, making comments and responding to questions. Generally, the evidence suggests that the PECS is an effective AAC system for individuals with ASD (Bondy & Frost, 1994; Chambers & Rehfeldt, 2003; May & Dymond, 2014; Lancioni et al., 2007; Magiati & Howlin, 2003; Schwartz, Garfinkle, & Bauer, 1998).

Although the PECS is a widely used and effective system (e.g., Charlop-Christy, Carpenter, LeBlanc, & Kellet, 2002), it is, along with other picture exchange systems, rather time- and labour-intensive (De Leo, Gonzales, Battagiri, & Leroy, 2011), which represents a significant practical challenge for parents and practitioners (Hayes et al., 2010; Leroy & De Leo, 2008). For instance, in order to use and maintain the system, caregivers must have the device available (i.e., not forgotten or left at home or school), select objects and take photographs, print, laminate, cut, and apply Velcro™, which takes a considerable amount of time. In addition, it is impossible for young children to be active initiators of this process due to the dangerous nature of the apparatus needed (i.e., hot laminators and sharp scissors). For young children then, the independence achieved by learning to communicate via the PECS is tempered somewhat by the set up and operation requirements of the system.

Other forms of AAC systems such as sign language and Makaton signs have potential limitations that necessitate caution when selecting them as a mode of communication intervention. For instance, a weakness with manual signing is that all communicative partners must be trained to use the system and this clearly restricts the verbal community with which individuals with developmental disabilities may interact. Unfamiliar listeners or potential communicative partners require training in the effective use of manual signing if they are to interact with a person with ASD using such an AAC system. Another limitation of other forms of AAC like manual signing is that such systems may not be a good fit for all children with ASD because of the fine motor skills involved. ASD is often highly comorbid with motor impairments (e.g., Green et al., 2009), and thus the fine movements, sequences and repetitions required to sustain a communicative exchange between two signers are often beyond the capability of many potential users. The development and validation of alternative AAC systems is therefore needed as a means of overcoming some of the limitations of existing methods.

Recent developments in communication technology have led to exciting advances in AACs (Sennott & Bowker, 2009). Portable electronic devices such as the iTouch™ (Apple Inc., Cupertino, CA) or Speech Generating Devices (SGDs) can simultaneously and substantially increase the size of the 'vocabulary store' (i.e., the number of pictures or symbols a device can hold) and decrease the size of a device (the PECS book is 25.5 cm by 23 cm, whereas the iTouch™ is 12.3 cm by 5.9 cm). In addition, new devices such as the iTouch™ require considerably less time to set up and maintain. Unlike picture exchange systems, there is no lengthy process to expand vocabulary stores, which can be as simple as taking a photograph with the device itself. Portable electronic devices also have the potential to facilitate child-led expansion of vocabulary stores by allowing the user to take the photos (although research is needed in this area to determine its' feasibility). Moreover, the widespread availability of small, socially acceptable devices such as the Apple iPad® (Apple Inc., Cupertino, CA) and the Google Android™ (Google Inc., Mountain View, CA) with the use of applications ('apps') have rapidly expanded the possibilities for AAC development. Between 2011 and 2013, the proportion of children (aged 8 and under) with access to some type of mobile device with Internet access at home (e.g., smartphone, tablet) has increased from half (52%) to three-quarters (75%; Common Sense Media & Rideout, 2013). Almost as many children (aged eight and under) now own their own tablets (7%) as their parents did two years ago (8%; Common Sense Media & Rideout, 2013). Additionally, SGDs and other

high-tech alternatives may provide more socially acceptable mode of communication for adolescents and adults than exchanging pictures.

Across all AAC devices, request training, or manding (Skinner, 1957), is often the initial focus of early intervention for individuals with developmental disabilities (Dixon, Small, & Rosales, 2007; Dymond, O'Hora, Whelan, & O'Donovan, 2006; Sautter & LeBlanc, 2006). This is perhaps unsurprising given that the ability to make requests is of primary benefit to the individual concerned and is a skill that leads to greater independence (LeBlanc et al., 2009; Rosales & Rehfeldt, 2007; Stafford, Sundberg, & Braam, 1988; Sundberg & Michael, 2001). As well as facilitating independence, challenging behaviour may also decrease once request training is implemented (e.g. Sigafoos & Meikle, 1996). These and other reasons indicate that increasing competence in requesting is a good fit for AACs as their primary purpose is to "compensate (either temporarily or permanently) for the impairment and disability patterns of individuals with severe expressive communication disorders" (American Speech-Language-Hearing Association [ASHA], 1989, p. 107).

1.1. Justification for current review and research questions

Few empirical studies have investigated the use of new high-tech AAC devices in facilitating independent communication skills, such as requesting. There are several reasons why it is timely to review the utility of widely available, app-based high-tech AAC devices. First, such devices are increasingly commonplace in clinical and educational settings (Wade, 2013). For instance, there are an estimated 265+ high-tech AAC apps available for iPhones®, iPods®, and iPads®. Second, as Knight, McKissick, and Saunders (2013) highlight: "teachers and parents should be knowledgeable about the advantages and disadvantages of any intervention they choose to adopt because each intervention has a cost, even if that cost is simply time." (p.19). Thus, it is necessary to optimise the time available to users when selecting apps and other high-tech devices for use with children with ASD. Third, it is an essential scientific requirement that any claims made about treatments for communication impairment in ASD using high-tech AAC devices should be rigorously evaluated and subject to empirical scrutiny (Green, 1996). Evaluating such claims is not only important for protecting users against the effects of potentially harmful devices but also because empirically-based treatment decisions give children with ASD the best chance of achieving their goals (Schreibman, 2000). Collating and summarising the existing state-of-the-art is one means of ensuring that treatment decisions are based on objective analysis of the available evidence.

Although several reviews of the AAC literature with individuals with ASD have been conducted (Kagohara et al., 2013; Lancioni et al., 2007; Mirenda, 2003; Schlosser & Lee, 2000; Schlosser & Wendt, 2008; van der Meer & Rispoli, 2010), none have focused exclusively on high-tech AAC devices incorporating both SGDs and newer app-based devices. For instance, Schlosser and Lee (2000) instead examined manual SGDs, while two further reviews compared the use of Voice Output Communication Aids (VOCAs) with graphic symbols (Lancioni et al., 2007) or manual signs (Mirenda, 2003). A further review by Schlosser and Wendt (2008) concentrated on the effects of AAC intervention on speech production only. Additionally, these reviews were conducted between 7 and 14 years ago and there is a need to update such analyses. Kagohara et al. (2013) only included iPod®, iPod Touch®, iPhone®, iPod nano® and iPad® based studies (including their use in academic, employment, and transitioning skills as well as communication) and, conversely, van der Meer and Rispoli's (2010) review included only studies that used SGDs. Kagohora et al. described only eight studies in the communication section of their review, which included studies conducted with participants with disabilities other than ASD such as Down syndrome and/or cerebral palsy. Also, studies involving SGDs other than iPods or iPads were not included in their review. Therefore, the aim of the current systematic review was to provide an up-to-date review of the empirical research conducted on teaching requesting skills using high-tech AAC devices with children with ASD. Reviewing the existing literature will aid evaluation of whether or not high-tech devices are effective in teaching requesting skills to children with ASD, and will help identify research gaps in need of further attention. The current review may also aid evidence-based decision making involving AAC devices in different clinical settings. Additionally, by charting the range and extent of research conducted with high-tech AAC devices, it will also identify trends in the use of older, low-tech devices.

The questions that are pertinent to examine in this review are as follows. What empirical research has been conducted on requesting skills with children with ASD using high-tech devices? What were the findings? Were they largely successful, varied or unsuccessful? What types of devices have been employed and do they adequately represent the range of devices available? What requesting skills were taught i.e. were basic requests or more in-depth requesting skills (such as distance and persistence, or requesting using sentences, or requesting information) included? What sorts of research designs were used to examine teaching the requests, and were the designs chosen effective for measuring the acquisition of requests? What communication skills did participants have, and were any formal language assessments conducted to measure this? What intervention strategies were used? These questions will help examine the efficacy of the included studies and determine potential future research directions.

2. Method and results

PubMed and Web of Science searches were performed using the search terms (augmentative) AND (alternative) AND (communication) AND (device) and were conducted without any restrictions on date, up to and including July 2013. Searches

returned 273 and 220 results for PubMed and Web of Science, respectively, which were screened for duplicates (10 were found). The remaining 483 papers were assessed according to the following inclusion criteria: contained original empirical research (i.e., not a review, methods paper or editorial); included human participants with diagnosis of an ASD, aged under 16; used a portable, electronic AAC; taught a functional requesting skill; and required selection- or topography-based responding (Sundberg & Michael, 2001). A further 477 articles were excluded after the duplicates; most were non-empirical (199) or had a diagnosis other than ASD or developmental disability (200). Thirty studies included participants who were over 16 years old and 19 used low-tech modes of communication (such as picture exchange). Thirteen studies were excluded because they did not teach a functional requesting skill and a further 16 were excluded because they involved the use of device adaptations not relevant to ASD, such as computer-brain interfaces. Six articles met these inclusion criteria.

Two further PubMed and Web of Science searches were conducted with the search terms (communication) AND (intervention) AND (autism), without any restrictions on date, up to and including October 2013. Searches returned 602 and 911 results for PubMed and Web of Science, respectively. A final two searches were subsequently conducted with the search terms (FCT) AND (autism) returned 13 and 21 results, respectively, 40 of which were duplicates.

The remaining 1547 papers were assessed according to the inclusion criteria described above. One thousand five hundred and thirty seven articles were excluded; most used low-tech modes of communication (such as picture exchange; 798) or did not teach a functional requesting skill (416). One hundred and seventy four were non-empirical. Sixty three were PhD abstracts. Twenty four studies included participants who were over 16 years old and a further 24 had a diagnosis other than ASD.

Ten additional articles met the inclusion criteria and, along with the six articles from the previous literature searches, formed the basis of the present review (see Table 1). The findings are considered using the following content headings, which arose from the research questions outlined earlier: mode of communication, skills taught, intervention methods, research designs, target set size, and main findings.

2.1. Mode of communication

We included mode of communication as a content heading to identify the different types of AAC devices used in the included studies. All 16 studies included the use of SGDs, four of which were iPod®- (the *Proloquo2go*™ application; AssistiveWare, Amsterdam, Netherlands) or iPad®-based (the *Pick a Word*© application; Red Mountain Labs, Inc. or the *Proloquo2go*™ application) devices. Seven studies used picture exchange (card-based) systems (Boesch, Wendt, Subramanian, & Hsu, 2013; Choi, O'Reilly, Sigafoos, & Lancioni, 2010; Flores et al., 2012; Son, Sigafoos, O'Reilly, & Lancioni, 2006; van der Meer, Kagohara, et al., 2012; van der Meer, Didden, et al., 2012; van der Meer et al., 2013) and three studies included the use of manual signing (van der Meer, Kagohara, et al., 2012; van der Meer, Didden, et al., 2012; van der Meer et al., 2013). Some of the studies (7) compared requesting skills across two or more modalities; either a SGD with manual sign and/or with a picture based system (Boesch et al., 2013; Flores et al., 2012; Son et al., 2006; van der Meer, Kagohara, et al., 2012; van der Meer, Didden, et al., 2012; van der Meer et al., 2013). Four studies used a single SGD device (Durand, 1999; Olive et al., 2007; Olive, Lang, & Davis, 2008; Sigafoos et al., 2004). Two studies (Sigafoos, O'Reilly, Ganz, Lancioni, & Schlosser, 2005; Schepis, Reid, Behrmann, & Sutton, 1998) compared different SGD devices (*BIGmack*™ switch vs. *Tech/Talk 6x8* vs. *Mini-messageMate*™ and *Cheap Talk* VOCA vs. *Black Hawk* VOCA, respectively). Schlosser et al. (2007) and Sigafoos, Didden, and O'Reilly (2003) compared active and inactive versions of the SGD (i.e. a speech output on and speech output off version to compare vocalisations in each condition) and Trembath, Balandin, Togher, and Stancliffe (2009) compared the presence and absence of an SGD on "communicative behaviours". The remaining study (Choi et al., 2010) utilised four devices used by participants at the time (picture exchange).

On examination of the prevalence of each modality it is clear that manual signing was used infrequently (3). This may, in part, be related to when the studies were conducted (i.e., between 1998 and 2013); in 2004, Tincani noted there was little new research on sign language interventions for children with ASD, perhaps because communication partners were unfamiliar with manual signs and hence unlikely to be capable of communicating with individuals who had learned to sign (Rotholz, 1989). If this is case, then it follows that the present findings confirm the rarity and low profile of manual signing as a facilitative communication intervention in ASD. Another possible reason for the fact that only three studies employed manual signing as a comparison procedure could be due to the extensive pre-requisites needed before manual signing is successfully mastered. For instance, successful use of manual signs relies heavily on an individual's imitative repertoire, while other forms of AAC require fewer skills prior to intervention (Carr & Dores, 1981). For these and other reasons, it is likely that the present findings further capture the decline of manual signing interventions in facilitating functional communication skills in ASD.

Apart from the three studies employing manual signing, we found that purpose built SGD devices were used more often than modern high-tech devices (e.g., iPod® or iPad® based devices). The well-established efficacy of SGDs with a variety of communication interventions for participants with developmental disabilities (van der Meer & Rispoli, 2010) is a possible explanation for their continued dominance over the newer, high-tech devices and suggests they may still have an important role to play in language intervention research. However, we maintain that future AAC research would do well to attend to the rapid growth in sales of high-tech devices, such as touch screen tablets, which sold 195.4 million units in 2013, a 68% increase on 2012 (Rivera & van der Meulen, 2014), and consider conducting further empirical research into their efficacy as AAC devices.

Table 1
Summary of empirical studies using high-tech AAC devices to teach functional communication skills to children with ASD.

Study	Mode of communication	Skills taught (vocabulary size)	Design (*n*)	Main findings	Formal language assessments	Intervention methods
Sigafoos et al. (2005)	*BIGmack*™ switch (AbleNet, Inc.) vs. *Tech/Talk 6x8* (Advanced Multimedia Devices, Inc.) vs. *Mini-messageMate*™ (Words+).	Request "I want more" for preferred food items (1).	Multiple baseline across participants design (2[a]).	Acquisition of the request "I want more" was successful. Similar rates of requesting were demonstrated for all 3 devices.	None included.	Most-to-least prompting. Researchers implemented procedures.
van der Meer, Didden, et al. (2012)[d]	*Proloquo2Go*™: iPod®-based speech-generating device (SGD) vs. manual signing (MS) vs. PECS.	A request for preferred food ($n = 1$) and toys ($n = 3$) e.g.: "I want to play" (1).	Multiple probe design across participants with embedded alternating treatment design (4).	Two participants successfully acquired requesting with all three modes, two could not achieve it with MS. Follow up was completed by 2 and successful with SGD but not MS or PECS.	*Vineland Adaptive Behaviour Scales* (Vineland-Z; Sparrow et al., 2003).	Most-to-least prompting. Researchers implemented procedures. R+ included verbal praise.
Olive et al. (2007)	*Cheap Talk 4 In-Line Direct*® VOCA.	Requests for preferred items (not specified, only frequency of "VOCA use" was recorded).	Multiple probe design across participants (3).	All participants displayed increased VOCA use from baseline levels of 0.	*Vineland Adaptive Behaviour Scales* (Vineland; Sparrow et al., 1985).	Most-to-least prompting. Taught teachers how to implement procedures.
Olive et al. (2008)	A four button *Touch Talk Direct*® VOCA.	Requests for attention during 4 activities, e.g.: "I want you to help me read" (4).	Multiple probe design across 4 activities (1).	Requesting increased across 2 activities from baseline with suggested generalisation effects then seen in the remaining 2.	*Expressive* and the *Receptive One-Word Picture Vocabulary Tests*, the *Expressive Vocabulary Test* (EVT) and the *Peabody Picture Vocabulary Test-III.*	Most-to-least prompting. Taught parents how to implement procedures.
Schepis et al. (1998)	*Cheap Talk* VOCA (Enabling Devices, Hastings-on-Hudson, NY) and *Black Hawk* VOCA (ADAMLAB Wayne, MI).	Requests for snacks, drinks, and toys (4–8).	Multiple probe design across time and across 2 participants in 2 routines and 2 participants in 1 routine (4).	All participants displayed an increase in communicative interactions during the VOCA and naturalistic teaching condition relative to baseline.	*Vineland Adaptive Behaviour Scales* (Version not indicated and reference not included).	Most-to-least prompting. Taught teachers how to implement procedures.
Durand (1999)	*Introtalker* SGD (Prentke Romich Company, Wooster, OH).	Requests selected according to suggested function of the problem behaviours (e.g. "I need help") (1).	Classroom: A (Baseline)–B (Intervention)–A (Baseline) design. Generalisation: multiple baseline across participants design. (5[b]).	Requests were successfully acquired for both participants; generalised into one community setting.	*Vineland Adaptive Behaviour Scales* (Version not indicated and reference not included) & the *Gesell Expressive Language Scale.*	Most-to-least prompting. Taught teachers how to implement procedures.
Sigafoos et al. (2003)	Active vs. inactive forms of *BIGmack*™ *switch* SGD (AbleNet Inc.).	Request "I want more" for preferred food, drinks, or toys (1).	Multiple baseline across participants design (3[c]).	Acquisition of the request "I want more" was successful. Similar rates of requesting were demonstrated for voice on/off comparisons.	None included.	Most-to-least prompting. Researchers implemented procedures.

van der Meer, Kagohara, et al. (2012)	*Proloquo2Go*™: iPod®-based speech- generating device (SGD) vs. manual signing (MS).	Requests for preferred toy, snack, or play (2).	Multiple probe across participants design & alternating treatments design, with follow-up (4).	Requests acquired with both formats for 3/4 with one not acquiring requests with MS; increased preference for, and faster acquisition of, SGD in 3/4 participants.	*Vineland Adaptive Behaviour Scales* (Vineland-II; Sparrow et al., 2005).	Most-to-least prompting. Taught teachers and parents how to implement procedures. R+ included verbal praise.
Flores et al. (2012)	*Pick a Word*©: iPad®-based SGD vs. picture-based system.	Requests for snack items (1–3).	Alternating treatments design (5).	Frequency of requesting using iPad® was either greater than, or equal to, the frequency using picture cards.	*Test of Language Development-Intermediate* (TOLD-I-4) (Hammill & Newcomer, 2008a) or the *Test of Language Development-Primary* (TOLD-P-4) (Hammill & Newcomer, 2008b).	Least-to-most prompting. Taught teachers how to implement procedures. R+ included verbal praise.
Son et al. (2006)	*Tech/Talk 6X8*® SGD (Advanced Multimedia Devices, Inc., Farmingdale, NY), vs. picture-exchange (Mayer-Johnson Co., Solano Beach, CA).	Requests for snack items (2).	A (Baseline) -B Intervention) design (3).	Comparable rates of acquisition with both modes; 2/3 participants preferred picture-exchange.	None included.	Most-to-least prompting. Researchers implemented procedures.
Trembath et al. (2009)	Presence vs. absence of *Talara-32* SGD.	"*Communicative behaviours*" (p. 176), such as speech, eye-gaze, SGD use, etc. (up to 8).	Multiple baseline across participants design (3).	Increased rate of communicative behaviours with a SGD; generalisation evident in 2/3 participants, but maintained at follow-up by 1 participant.	None included.	Most-to-least prompting. Taught typically developing peers how to implement procedures.
Schlosser et al. (2007)	Active vs. inactive forms of *Vantage*™ SGD (Prentke Romich Company, Wooster, OH).	Requests for food and leisure items (8).	Alternating treatments design (5).	Increased requesting with active SGD in 2/5 participants and with inactive SGD in 1/5; 2 showed no difference.	*Receptive-Expressive Emergent Language Scale* (Bzoch & League, 1991).	Most-to-least prompting. Researchers implemented procedures.
Choi et al. (2010)	*Vantage*™, *Tech Speak*® (Advanced Multimedia Devices, Inc. Farmingdale, NY.), *Springboard*® SGDs (Prentke Romich Company, Wooster, OH) and picture-exchange.	Requests for missing items (4–6).	Multiple probe across participants design (4).	All participants acquired target requesting and rejecting responses which generalised across 2 settings and were maintained at follow-up for 3/4.	*Adaptive Behavior Assessment System* (Harrison & Oakland, 2003).	Most-to-least prompting. Researchers implemented procedures.
Boesch et al. (2013)	Five-button *Logan Pox Talker* SGD vs. *PECS*.	Requests for preferred food items (8).	Multiple probe across participants with imbedded alternating treatment design (3).	All participants acquired basic exchange, and distance and persistence, requesting with both devices and with the one device brought through to follow up and generalisation. No participant met criterion with phase III (discrimination training) with either modality.	*MacArthur-Bates Words and Gestures Communication Development Inventory* (CDI; Fenson et al., 2007)	Most-to-least prompting. Researchers implemented procedures.

Table 1 (*Continued*)

Study	Mode of communication	Skills taught (vocabulary size)	Design (*n*)	Main findings	Formal language assessments	Intervention methods
van der Meer et al. (2013)	*Proloquo2Go*™*:* iPod® and iPad®-based speech-generating device (SGD) vs. *Makaton Sign Language System* (MS) vs. PE.	Requests for preferred food and activities (8). Additionally etiquette phrases of "I want" and "please" were taught with requests.	Alternating treatment design (2).	One participant reached criterion for 1-step requesting the item (not including the "I want") using all modalities. The second participant reached criterion using SGD and PE but not MS even after modified teaching procedures were introduced.	*Vineland Adaptive Behaviour Scales* (Vineland; Sparrow, Cicchetti, & Balla, 2005).	Most-to-least prompting. Taught parents how to implement procedures. R+ included verbal praise.
Sigafoos et al. (2004)	*Talk-Trac Wearable Communicator*™ VOCA (AbleNet Inc.).	Requests for preferred food, drinks and activities (4).	A (Baseline) -B Intervention) design (1).	The participant reached 100% correct requesting from 0% at baseline.	*Vineland Adaptive Behaviour Scales* (Vineland-II; Sparrow, Balla, & Cicchetti, 1984) & *Receptive-Expressive Emergent Language Scale* (Bzoch & League, 1991).	Most-to-least prompting. Taught parents how to implement procedures. R+ included verbal praise.

Note: Some participants did not meet the inclusion criteria of the present review: [a] In Sigafoos et al. (2005), one of the three; [b] in Durand (1999), two of five; and [c] in Sigafoos et al. (2003), only one of the two participants' data were considered in the current review. [d] Indicates graph from erratum for van der Meer, Didden, et al. (2012).

2.2. Skills taught

We identified the skills taught in the different studies with the various AAC devices used, and whether or not the requests were for preferred or non-preferred items or activities. Thirteen out of the 16 studies taught requesting skills for preferred food or toys. One study taught requests for attention (Olive et al., 2008) and one other (Durand, 1999) taught requests according to the suggested function of each participants challenging behaviour. The remaining study (Trembath et al., 2009) used typically developing peers to teach three children with ASD the use of eight words or messages (i.e., "*yes*", "*good*", "*don't*", "*no*", "*more*", "*I want*", "*help*", *and* "*finish*"). The authors justified using these particular words and sentences because the typically developing peers had used them frequently (Trembath, Balandin, & Togher, 2007), they could be used to indicate not only requesting, but also rejecting and commenting, and could be used in a variety of settings. Flores et al. (2012) chose three snacks and juice and children could request whichever of the four items they preferred. In addition to requesting skills, Choi et al. (2010) also taught rejecting skills and re-requesting skills (i.e., the ability to persist and ask again if the wrong item was offered). Similarly, van der Meer et al. (2013) taught skills other than requesting, including greetings (hello and goodbye), etiquette (please and thank you), answering (yes/no) questions.

Flores et al. (2012) included three different food items and a drink that were offered during daily snack time. Children were allowed to request preferred items; however, no formal preference assessments were conducted on the items. Olive et al. (2007) also conducted no formal preference assessments; instead they presented children with three items from each child's classroom at the beginning of each session and asked, "What do you want to play with today?" varying items between sessions. Sigafoos et al. (2005) utilised six items that had been identified as preferred via staff reports and informal observations. Sigafoos et al. (2003) conducted informal assessments with two out of the three participants' parents to ascertain what their preferred foods, drinks, and toys were. From these lists, a variety of potential reinforcers were assembled, of which three or four were available to participants during experimental sessions. For the third participant the food that he had brought with him for lunch and a basketball was used, because the intervention occurred at lunchtime. When selecting items to be requested, the experimenter in Schepis et al. (1998) study provided information on participants' preferences based on observations of the items the child had selected in a free-choice situation and the amount of time a child had engaged with each item. Classroom staff and the experimenter also discussed the types of communication messages that would provide the child with the most useful communicative responses in terms of frequency of use and function. Durand (1999) conducted an informal choice assessment for tangible items used in the access to tangible condition of the functional communication training, and other requests were unsuitable for inclusion on a specific preference assessment (such as escape and attention). Schlosser et al. (2007) and Boesch et al. (2013) conducted a three stage preference assessment: including an interview with parents and teachers. This was then followed by two formal preference assessments which employed the objects from the parental/teacher interview (Sigafoos & Reichle, 1992). Choi et al. (2010) asked teachers to nominate preferred activities that each participant liked and from this list a single stimulus presentation preference assessment was conducted to identify activities to include in the study (Pace, Ivancic, Edwards, Iwata, & Page, 1985). van der Meer, Kagohara, et al. (2012), van der Meer, Didden, et al. (2012) and van der Meer et al. (2013) utilised a systematic two-stage stimulus assessment (Green et al., 2008) consisting of an indirect and a direct assessment. The indirect assessment consisted of asking the teachers to list items that the children preferred; the most preferred items were then included in a multiple stimulus without replacement preference assessment (DeLeon & Iwata, 1996; Duker, Didden, & Sigafoos, 2004). In Olive et al. (2008), the participant's mother selected the activities used on the basis of indirect reports. Parents in the Son et al. (2006) study were asked to list food that the children appeared to enjoy, and from those lists, a single item preference assessment was conducted (DeLeon & Iwata, 1996). Sigafoos et al. (2004) conducted a preference assessment (Duker, Didden, & Sigafoos, 2004) to identify preferred food, drink and activities. Due to the nature of the vocabulary chosen by Trembath et al. (2009), the words could not be included in a preference assessment (i.e. they were not actual food, drinks or toys).

2.3. Intervention methods

We identified the intervention methods used by determining who conducted training sessions where training was conducted, what types of teaching procedures were used, and what prompts and what reinforcement procedures were employed. Applied behaviour analysis techniques were employed by all studies with 14 out of 16 using a least-to-most prompting strategy (only Boesch et al. (2013) and Olive et al. (2007) used most-to-least prompting). Three studies taught parents how to implement procedures (Olive et al., 2008; Sigafoos et al., 2004; van der Meer et al., 2013), four taught teachers (Durand, 1999; Flores et al., 2012; Olive et al., 2007; Schepis et al., 1998) and one taught a mixture of both (van der Meer, Kagohara, et al., 2012). The remaining studies used dedicated researchers to teach the requests, except for Trembath et al. (2009) who taught typically developing children to work with their autistic peers. Reinforcement was provided for requests via immediate delivery of requested items in all studies, with some using additional verbal praise.

Flores et al. (2012) provided instruction for use of the iPad using a least-to-most prompting procedure. Two adults were present during instruction, the class teacher and the experimenter. Initially, children were provided with explicit instruction of the relation between the pictures and the items. When participants could independently match the food to the corresponding pictures three times, and the experimenter and the teacher both demonstrated a correct request using the iPad. Then, the student was instructed to request a snack by the teacher – if they did not respond within 5 s they were given a

verbal prompt to touch the iPad, and if they did not respond again within 5 s they were given a physical prompt by the experimenter. Reinforcement was provided in the form of delivery of the desired item and verbal praise.

Three adults were present during the first two phases of the study by Sigafoos et al. (2004): the participant's mother, a trainer, and a reliability observer. During sessions, the *TalkTrac* device was attached to the participant's wrist and request training was provided in three settings (a café, by a vending machine, and finally at the participant's home). Initial requests were prompted when the participant reached for items displayed on a tray, after the experimenter said, "let me know if you want something". The least amount of physical guidance necessary was used to prompt a correct response. Independent and prompted requests were reinforced with access to the requested item and verbal feedback. Training was the same in both the café and vending machine settings, with the final home-based phase conducted by the participant's mother, sister, and a family friend. Procedures were emailed to the parent and discussed via telephone calls, and sessions were video recorded and sent to the experimenters for feedback.

Three participants in van der Meer, Kagohara, and colleagues' (2012) study received training in their homes with their mothers and the remaining participant participated in her school with her teaching assistant. The mothers and teaching assistant were taught how to implement the teaching procedure by the experimenter (first author), who used written instructions, modelling, observation, and feedback. Graduated guidance (a least-to-most prompting strategy) was used to prompt correct requests. Immediately after a correct independent or prompted request participants were given 20 s access and social praise. Items, once requested and chosen, were not replaced on the tray to ensure all requests had equal opportunities to be learned. One of the three AAC devices was placed on the table in front of the participant (counterbalanced across sessions) along with a tray full of toys or snacks (in view but out of reach). Participants were told, "let me know if you want this" to signal that the items were on offer. One or two additional observers were sometimes present to conduct inter-observer agreement (IOA) and procedural integrity checks.

van der Meer, Didden, et al. (2012) conducted sessions in the participants' school with the first author assuming the role of trainer. Training sessions were conducted in the same way as van der Meer, Kagohara, et al. (2012) study.

The first participant in van der Meer and colleagues' (2013) study had his sessions at home with his mother as the instructor. Procedures for parent training were the same as used in van der Meer, Kagohara, et al. (2012). The second participant in the 2013 study had her sessions in school with the first author because her mother expressed reservations about carrying out the procedure. Teaching procedures were also similar to van der Meer, Kagohara, et al. (2012), with the following exceptions. The first participant was asked, "what do you want to play with/eat?" and the second was instructed, "ask to play with [name of item]" to signal that the items were on offer. If no request was made after 10 s, the tray was offered to participants. In the intervention phase there was also a correspondence check where items physically selected from the tray had to match the item requested for. If the items did not match, then the instructor said "you requested [name of item]" or "we are requesting [name of item]" and prompted the correct response with a least-to-most prompting strategy.

Enhanced milieu teaching (EMT; a naturalistic communication intervention) was used in Olive et al. (2007) and consisted of the adult taking the child's lead during play, imitating the child's play and used environmental arrangement strategies to promote requesting. Sessions were conducted with the class teacher in the participants' schools. An independent observer was sometimes present for integrity and IOA checks. Teachers used a most-to-least prompting strategy. The requests were reinforced by access to the desired items along with an expanded verbal statement to the VOCA such as, "you want the cars!"

Olive and colleagues' (2008) case study involved one participant and her mother in functional communication training (FCT) to replace problem behaviour (with the function identified as attention seeking by a functional analysis) with requests for attention (engagement with the mother in different activities). Training procedures for the mother included written information about FCT, modelling, and coaching with a researcher. The coaching was gradually faded out. Teaching sessions began with mother and child playing, the mother leaving and immediately returning and prompting her daughter to request attention using the VOCA and a graduated guidance prompting strategy. The mother gradually faded the prompts until her daughter was requesting independently.

Schepis and colleagues' (1998) study was conducted in the participants' school with seven children present, one teacher and one or two assistants. Two experimenters were sometimes present for IOA and integrity data collection. One child was selected for naturalistic intervention at a time. Training for staff consisted of verbal and written information about the naturalistic teaching procedures and VOCA use. The strategies employed included using preferred items, using child-initiated behaviours as the indicator for opportunities to request, verbal and gestural prompts with minimal use of physical guidance.

Sessions for the participant in Sigafoos and colleagues' (2003) study were conducted in an outpatient's clinic room at a children's hospital with the participant and his mother and the experimenter (with teaching being carried out by the experimenter). Sessions began with the participant being given some of the food or drink or 10 s with the toy then the experimenter saying, "let me know if you want more". Items were kept on a tray in view but out-of-reach of the participant. When the child reached to gain access to the items, the trainer used least-to-most prompts to guide the child to press the correct button for 'more'. Prompted and independent requests were reinforced with access to more of the item. Correct vocal requests were also reinforced in this way.

Sigafoos et al. (2005) conducted sessions in the participants' school. Procedures were similar to Sigafoos et al. (2003). Teaching included additional steps such as turning the device on, requesting, and picking the item from the shelf where it was stored, and returning to the table.

Two participants in Boesch et al. (2013) participated in sessions in a university speech clinic therapy room and the third participated at home. Three experimenter-trainers conducted sessions with all participants to encourage participants to

communicate with several partners. Training procedures mirrored that of PECS training protocol (Frost & Bondy, 2002). Some examples of techniques employed were one trainer served as a communicative partner and another as a prompter, a most-to-least prompting strategy was used, and prompts were gradually faded and eliminated. Reinforcement in PECS training consists of immediate access to the requested items.

Sessions in Durand (1999) were carried out in participants' schools with their teachers. Training for the teachers consisted of attending workshops about FCT consisting of information about how to teach the use of AAC devices and assistance in developing individualised plans of instruction for each child. Requests were selected according to the function of each child's challenging behaviour via a functional assessment. Reinforcement was provided in the form of the requested behaviour being performed (e.g., help was given). Teachers used graduated guidance to prompt participants, which was gradually faded.

Teaching sessions in Son et al. (2006) were conducted in kitchens in the participants' family homes. The first author taught participants in sessions initiated by offering the child a single snack item. If children did not make a request within 10 s, the trainer prompted a correct response using a least-to-most prompting strategy. Correct requests were reinforced by the delivery of the snack item.

Trembath et al. (2009) taught typically developing children to implement naturalistic teaching procedures with their autistic peers at their respective preschools. Teaching with the typically developing children was delivered through stories with illustrations, modelling, and suggestions of activities the children could play with together. The typically developing children were instructed to show their peer with autism something, wait to see if he wants to play and tell him what you are doing (show, wait, and tell). Children mediating were reminded prior to and during the intervention sessions to show, wait, and tell. No prompt or fading strategies were described other than these for the request intervention sessions. Specific consequences for each communicative behaviour (*yes*, *good*, *don't*, *no*, *more*, *I want*, *help*, and *finish*) were not explicitly outlined, probably because they were context specific.

Participants in Choi et al. (2010) were included in one-to-one sessions in their schools with the experimenter. Training was conducted to teach children to request for missing items needed to complete each activity. These sessions were initiated by the experimenter instructing the participant to engage in a particular activity (e.g., "drink the juice") with part of it missing (e.g., the straw). Gestural prompts and progressive time delay were used to promote correct responding and if participants did not then request the item, a gestural prompt (pointing to the item needed) was combined with a verbal prompt ("what do you need?"). Rejecting and re-requesting was then taught to participants where an incorrect and incongruent item would be delivered (e.g., a ball instead of a straw needed to drink the juice) again using gestural prompts and progressive time delay. Rejecting was reinforced with immediate removal of the incorrect item and correct re-requesting was reinforced by 15 s access to the correct item.

2.4. Formal language assessments

In order to identify the range of language abilities employed in AAC research, we recorded the type of formal language assessment scales used. Eleven different formal language assessments were used to quantify participants' receptive and expressive communication skills and other adaptive behaviour. Four studies did not include any standardised assessments (Son et al., 2006; Sigafoos et al., 2003, 2005; Trembath et al., 2009). The remaining studies employed scales such as the *Test of Language Development-Intermediate* (TOLD-I-4; Hammill & Newcomer, 2008a), *Test of Language Development-Primary* (TOLD-P-4; Hammill & Newcomer, 2008b), *Receptive-Expressive Emergent Language Scale* (Bzoch & League, 1991), *Adaptive Behavior Assessment System* (Harrison & Oakland, 2003), *Gesell Expressive Language Scale*, the *Expressive* and *Receptive One-Word Picture Vocabulary Tests*, the *Expressive Vocabulary Test* (EVT), *Peabody Picture Vocabulary Test-III*, and the *MacArthur-Bates Words and Gestures Communication Development Inventory* (CDI; Fenson et al., 2007) to assess participants' pre-existing language abilities. The *Vineland Adaptive Behaviour Scales* (Vineland-Z; Sparrow, Balla, & Cicchetti, 2003; Vineland; Sparrow, Balla, & Cicchetti, 1984; Sparrow, Balla, Cicchetti, & Doll, 1985; Vineland-II; Sparrow, Cicchetti, & Balla, 2005) was used by six of the sixteen studies to assess adaptive social behaviour prior to intervention (Durand, 1999; Olive et al., 2007; Schepis et al., 1998; Sigafoos et al., 2004; van der Meer, Kagohara, et al., 2012; van der Meer, Didden, et al., 2012; van der Meer et al., 2013). The scales were used prior to intervention phases (in the information describing participants' communication skills) in all studies, but were not used again post-interventions.

2.5. Research designs

We noted the research design used because the type of experimental design is a key criterion used to assess whether a study can be classified as evidence based or not (Gersten et al., 2005; Horner et al., 2005; National Autism Center, 2008). Four of the studies used multiple probe designs across participants (Choi et al., 2010; Olive et al., 2007), activities (Olive et al., 2008), or participants (Schepis et al., 1998), with three additional studies (van der Meer, Kagohara, et al., 2012; van der Meer, Didden, et al., 2012; Boesch et al., 2013) employing multiple probe design with an embedded alternating treatments design. Three studies used a multiple baseline design (Trembath et al., 2009; Sigafoos et al., 2003, 2005), three used alternating treatments designs (Flores et al., 2012; Schlosser et al., 2007; van der Meer et al., 2013), one study used and A-B-A design for the intervention followed by a multiple baseline design for the generalisation phase (Durand, 1999), and the final two studies employed an A-B design (Sigafoos et al., 2004; Son et al., 2006).

The most commonly used design was the multiple baseline design (or a variant, such as the multiple probe design; Christ, 2007; Horner & Baer, 1978). Both the multiple baseline and multiple probe designs involve simultaneous baseline data collection with two or more participants, behaviours, or settings. After stable responding is achieved with the first factor, the independent variable is applied to while baseline conditions are maintained for the others. After a reliable change is observed in the first factor, the independent variable is then applied sequentially to each factor in the design. On the other hand, the A-B design involves just two phases, baseline (A) and intervention (B), which makes demonstrating functional relations between the treatment variable and behaviour change difficult.

Findings of the review on the types of research designs used in high-tech AAC research with children with ASD clearly shows a preference for single-case research methodology generally (Kennedy, 2005), and multiple baseline designs specifically. As discussed, such designs are the most appropriate and effective way of demonstrating functional control over the targeted requesting behaviour and have been employed in recent research on derived requesting interventions (e.g., Rosales, Stone, & Rehfeldt, 2009).

2.6. Vocabulary size

Vocabulary size was also identified from the studies because the number of words taught is a likely contributor to the perceived social validity of a high-tech AAC intervention. Across the 16 identified studies, the highest number of target skills taught was eight (Boesch et al., 2013; Schlosser et al., 2007) and the lowest number was one (Durand, 1999; Sigafoos et al., 2003, 2005; van der Meer, Kagohara, et al., 2012; van der Meer, Didden, et al., 2012). Two studies measured other dimensions such as frequency of requesting or rate of acquisition and did not measure target stimulus set size at all (Flores et al., 2012; Trembath et al., 2009). They did, however, have the same range of potential target skills (between one and eight responses) as the other studies. Unfortunately, many studies did not report the number of requests successfully acquired, which therefore makes an evaluation of the teaching procedures difficult.

The limited stimulus set sizes used in these studies suggest caution is needed when considering results and that interpretation is limited by the fact that teaching between one and eight requests does not represent a typical vocabulary range. For these and other reasons, further research is needed on developing methods to increase vocabulary size and use in the absence of directly teaching every request (e.g., Rosales & Rehfeldt, 2007).

2.7. Main findings

We will now summarise the main reported findings of the studies by describing the percentage change from baseline to treatment. In all studies, participants' requesting skills either increased from baseline or were successfully acquired with at least one communication system (manual sign, picture exchange, SGD). Schlosser et al.'s (2007) first participant's mean scores increased from baseline to intervention in the no-speech condition (where the SGD device had the voice output disabled) by 59.5% of correct vocalisations and 73.3% of correct vocalisations in the speech condition (where the SGD device worked as normal). The second participant's mean scores increased from baseline to intervention in the no-speech condition by 84.3% and 81.2% in the speech condition. The third participant had mean scores that increased from baseline to intervention in the no-speech condition by 48.3% and 55.1% in the speech condition however his mean performance for the intervention sessions were 71%; he did not reach the learning criteria in either condition. The fourth participant's mean scores increased from baseline to intervention in the no-speech condition by 98.7% and 80.4% in the speech condition, while the fifth participant had mean scores that increased from baseline to intervention in the no-speech condition by 89.2.3% and 85% in the speech condition.

In Choi et al. (2010), requesting trials needed to achieve criterion for missing items were ranged between 90 and 206. Participants all achieved less than 5% correct on rejecting and re-requesting trials during baseline. During training phases, three of the participants reached criterion within 8–10 sessions and another at session 11 (following 7 sessions of intensive training).

In van der Meer, Kagohara, et al. (2012), the first participant achieved acquisition of requests using manual signing (MS) on his 6th MS session and he achieved acquisition of requests using the SGD on his 13th SGD session. In the 2 week follow up he used MS with 100% proficiency. He achieved 100% correct requesting with MS, but 40–60% with SGD at 1-month follow-up. At the 6 month follow-up, the first participant achieved 90–100% MS use and 100% SGD. Preference assessments were conducted throughout the study for participants to select their favourite AAC device. Overall, he selected the MS on 55% of preference assessments. The second participant achieved criterion requesting using SGD on his 6th session and with MS on his 24th session. He achieved a "high level" of correct requesting using the SGD at the 1-month follow-up. His MS use ranged from 0 to 40% correct. At 6-month follow-up, the second participant's proficiency for SGD was 100% and MS use was 0%. Overall, he chose SGD in 89% of preference assessments. The third participant achieved criterion requesting with the SGD on his 14th session but did not reach criterion with MS. He maintained 80–90% requesting with SGD and 0% with MS at the 1-month follow-up and 80–90% correct requesting and 6-month follow-up (his MS was at 0%). Overall, he chose SGD 92% of preference assessments. The fourth participant achieved criterion with SGD on his 3rd session and with MS on his 10th session. At the 1-month follow-up he achieved 30–50% with SGD and 10% with MS and at the 6-month follow-up he scored 40–60% correct with SGD and 0–20% with MS. Overall, he chose the SGD on 100% of preference assessment trials.

Results from Son et al. (2006) showed no correct requesting during baseline. The first participant had a stabilised performance at 75–87.5% correct with VOCA and 75% with picture-exchange. The second participant performed at 100% correct with both devices and the third participant reached 100% with VOCA and 87.5 with the picture-exchange system. Preferences for the devices were as follows: the first participant chose VOCA 94% of 32 opportunities, the second chose picture-exchange on 98% of 88 opportunities and the final participant chose picture-exchange on 72% of 72 opportunities.

Analysis of the combined data for the three children in Trembath et al. (2009) indicates that increases in communicative behaviours were statistically significant from baseline to the peer mediated naturalistic teaching phase. They increased significantly again from that condition to the added SGD and naturalistic teaching phase.

In Flores et al. (2012), a comparison was made between a picture card based communication system and the iPad®-based application: *Pick a Word*© (Red Mountain Labs, Inc.). The mean number of communicative behaviours during each phase of their alternating treatment design was first displayed for an iPad® phase, a second picture phase, a second iPad® phase, and a final picture phase. The first participant's mean iPad® use was14.6 (SD = 6.05), which was more frequent than his use of picture exchange (M: 3.5, SD = 2.54). The second participant made use of picture exchange less often lower than the iPad® (M: 9.9, SD = 1.96; M: 13.3, SD = 1, respectively). The third participant's mean iPad® use (33; SD = 9.7) was much more frequent than his picture exchange (2.8, SD = 1.87), while, the fourth participant's mean number of communicative behaviours with the iPad® was 17.7 (SD = 0.35), which was more frequent than his picture exchange use (M: 8.2, SD = 0.96). The final participant, had a mean number of communicative behaviours of 12.9 (SD = 2.97) during the picture exchange phases and 17.1 (SD = 3.5) with the iPad®. In summary, four out of five participants communicated more frequently during the iPad® phases than the picture exchange phases.

In Boesch et al. (2013), no statistically significant differences were found between AAC strategies for any participant during any phase. The first participant increased requests from average of 0.8 times with PECS and 0 with SGD in baseline to 15.7 with PECS and 15 with SGD in phase 1 of PECS (direct exchange). In phase II (distance and persistence), he demonstrated increased use of PECS (16) over SGD (9) and during phase III (picture discrimination) criterion was not met. The second participant's requests increased from average of 1.4 times with PECS and 0 with SGD in baseline to 13.8 with PECS and 9.5 with SGD in phase 1 of PECS. In phase II she requested a mean of 11.3 times with SGD and 8.9 times with PECS. During phase III she also failed to reach criterion. The final participant did not request with either AAC during baseline which increased to an average of 12.2 with PECS and 13.8 with SGD in phase I. In phase II, he requested on average 11.2 times with PECS and 8 with SGD. He also failed to achieve criterion with phase III.

Sigafoos et al. (2005) reported no requests for either participant during baseline and both achieved criterion with all devices quickly. Participant one achieved criterion requesting within 30 opportunities with all three devices (BIGmack™ switch, Tech/Talk 6x8, Mini-messageMate™) and participant two achieved criterion levels of requesting within 37, 40, and 30 opportunities respectively for each device.

In van der Meer, Didden, et al. (2012), the first participant reached acquisition criterion for SGD on his third training session, but did not reach it with the MS or PE modalities. The second participant did not reach acquisition criterion for SGD, MS, or PE. The third participant reached acquisition criterion for SGD and PE on his third sessions each and for MS on his sixth session. The final participant reached acquisition criterion for PE and SGD on her fourth and eighth sessions respectively. She reached acquisition criterion for MS on her 34th session.

Results from Olive et al. (2007) showed all three participants increased their average frequency of VOCA use per session from zero rates at baseline to 10.5, 7.3 and 12.8 respectively. Olive et al. (2008) showed the participants requesting skills increased from zero baseline levels of requesting per five-minute session to an average of 2.9 with art, and to 3.6 with reading. The researchers suggested that the average number of requests (3.6 and 2.9) made during a memory task and puzzles during baseline were due to generalisation of the taught requesting skills to novel tasks. The average number of requests made during a memory task and puzzles were at 2.25 and 2.5 during intervention sessions respectively.

Schepis et al. (1998) found that all communicative interactions increased during the VOCA and naturalistic teaching condition relative to baseline for all children. The four participants demonstrated an average of communicative interactions per minute of 0.05, 0.02, 0.16, and 0.07 during baseline which increased to 2.85, 2.56, 3.94, and 3.29 for the snack condition. Percentages of those interactions that were made using the VOCA averaged 93%, 82%, 89%, and 36%. During the play condition (which only two participants took part in) their average number of communicative interactions per minute increased from 0.09 and 0.11 (during baseline) to 3.55 and 2.57 in the intervention stage with 87% and 86% of those being made using the VOCA.

Results from Sigafoos et al. (2003) show that the participant acquired the targeted requesting skills in a 20-minute session. An increasing rate of requesting across sessions to a high level (70–90% of the 20-s intervals) was achieved but there were no consistent differences in the rates of requesting over on versus off conditions of the post-acquisition comparison. Sigafoos et al. (2004) found that correct requesting increased from 0% at baseline to 100% with all requests (food, drink, music, and drawing) at intervention.

Durand (1999) reported pre-intervention baseline levels of unprompted use of AAC devices for the two participants to be zero. Following the intervention (FCT), the mean percentage of intervals in which the AAC device was used increased to 9% and 15%.

The results from van der Meer et al. (2013) show that the first participant achieved criterion requesting with all three devices with an increase in average scores of 38% to 86% using the SGD, an increase from 88% to 97% using PE, and an increase of 38% to 63% using MS. The second participant, increased her requesting from 31% to 68% in the first intervention (utilising

the same teaching strategy as with the first participant), then in the second intervention (using a higher intensity teaching strategy) she increased her requesting again to 92% with SGD. She increased her requesting using PE from 50% to 91% to 96% and using MS from 13% to 28% to 50%.

Horner et al. (2005) used quality indicators (QIs) to assess single-case research studies such as outcomes measured beyond immediate post-test (i.e., in generalisation or maintenance phases). Of the studies identified, only six examined requesting skills in follow-up sessions (Boesch et al., 2013; Choi et al., 2010; Schlosser et al., 2007; van der Meer, Kagohara, et al., 2012; van der Meer, Didden, et al., 2012; van der Meer et al., 2013) and three studies included programmed generalisation phases (Choi et al., 2010; Sigafoos et al., 2004; Trembath et al., 2009). Results varied widely in the six studies that included follow-up sessions, with only two studies reporting success with all included participants. Two studies found that three of the four participants were successful with at least one AAC modality. The final two studies only found that one participant used their AAC successfully at follow-up. It can be concluded that results from generalisation results were largely successful: one study demonstrated success across two novel settings and two participants out of three in the second study successfully generalised communicative responses. The final study found that requests were successfully taught on the VOCA in a new environment. The present findings that outcomes varied widely in follow up highlight that the quality of future investigations with high-tech AAC devices could be enhanced by the inclusion of follow up and/or generalisation phases (Horner et al., 2005).

3. Discussion

In this review, the results of high-tech AAC device studies published between 1998 and 2013 with children with ASD were located through keyword literature searches. Results were filtered according to the inclusion criteria and subsequently summarised and discussed. The present review provides an overview of the research published within the last 15 years on empirical studies using high-tech devices to teach functional communication skills to children with autism. Our findings show that the intervention aims of included studies were largely successful: all participants' requesting skills either increased from pre-tests and/or were successfully acquired with at least one communication modality.

On examination of the prevalence of each mode of communication it is clear that the use of SGDs was frequent (16 studies) compared to manual sign use (3 studies). Despite the recent developments in communication technology producing exciting advances in AAC systems (Sennott & Bowker, 2009) and the numerous improvements in portability and increased vocabulary store size, etc. only four of the 16 studies using SGD's were iPod®- (*Proloquo2go*™ application; van der Meer, Kagohara, et al., 2012; van der Meer, Didden, et al., 2012; van der Meer et al., 2013) or iPad®-based (*Pick a Word*© application; Flores et al., 2012; the *Proloquo2go*™ application; van der Meer et al., 2013) devices. Future research would do well to attend to the rapid growth in sales of high-tech devices, such as touch screen tablets, which sold 195.4 million units in 2013 (Rivera & van der Meulen, 2014), and consider conducting further empirical research into their efficacy as AAC devices. The findings from the current systematic review differ from previous reviews conducted on ASD and AAC (Lancioni et al., 2007; Mirenda, 2003; Schlosser & Lee, 2000; Schlosser & Wendt, 2008; van der Meer & Rispoli, 2010) by highlighting the deficits in the literature base with regards to new and high-tech devices.

Thirteen out of the 16 studies taught requesting skills for preferred food or toys; one study taught requests for attention (Olive et al., 2008); one study taught requests according to the function of challenging behaviour (Durand, 1999); the remaining study taught eight words or messages (*yes, good, don't, no, more, I want, help*, and *finish*; Trembath et al., 2009).

The most commonly used design was the multiple baseline design (11; or a variant of that design such as the multiple probe design; Christ, 2007; Horner & Baer, 1978). Three studies used an alternating treatments design alone (Flores et al., 2012; Schlosser et al., 2007; van der Meer et al., 2013). One study used an A-B-A design in addition to the multiple baseline (Durand, 1999) and two studies used an A-B design (Son et al., 2006). Although it is important that the research design chosen fits the behaviours being measured (it is impossible for skills such as requests to be unlearned, as required in a withdrawal design), the threats to internal validity in A-B designs should be carefully considered before selecting this design. In the context of facilitating independent communication skills, the A-B design has several important limitations. First, it is difficult to determine with a single introduction of an intervention that any resulting changes from baseline were due to the treatment or to other uncontrolled variables. In other words, demonstrating a functional relationship between the treatment variable and behaviour change is difficult in A-B designs. The addition of several applications of the independent variable to the dependent variable across different factors (as occurs with multiple baseline designs) allows for increased confidence that any changes seen are due to the independent variable and not some other variable. Second, the internal validity of A-B designs may be improved by reintroducing and withdrawing each phase (i.e., A-B-A-B) or just returning to baseline (i.e., A-B-A). Finally, it is important that the research design chosen fits the behaviours measured because skills once taught cannot be un-learned (the problem of 'behavioural irreversibility'). In this case, using a withdrawal design would not be appropriate for requesting behaviours taught using high-tech AAC devices. The multiple baseline design and its variants control for these threats and so seem to be the most appropriate and effective way of demonstrating success with the requesting behaviour. The basic literature on derived requesting also supports the use of this design (Rehfeldt & Root, 2005; Rosales & Rehfeldt, 2007; Rosales et al., 2009).

The range of potential target requesting skills for all the studies was between one and eight responses. However, one to eight words do not represent the wide range displayed in a typical vocabulary. This is one of the reasons why the exploration

of increasing vocabulary in the absence of directly teaching every request is important, such as with the inclusion of derived stimulus relations.

Kagohara et al. (2013) suggest caution when looking at the successful results examined in their literature review because of the limited participant numbers (less than 50) with a broad range of ages (4 to 27), diagnoses, and abilities. A total of 46 participants met our inclusion criteria across the 16 identified studies. All of the participants were under the age of 16, had a diagnosis of autism, and were using an AAC device. This focuses the range of diagnoses, degrees of language ability, and ages compared to the broader field examined by Kagohara and colleagues, thus strengthening support for the effective use of technological devices with this specific population for requesting skills. These results, then, can provide clinicians' with a growing supportive evidence base for the use of AAC devices with children with ASD.

Developments in communication technology have led to exciting advances in AAC systems (Sennott & Bowker, 2009). There are several advantages of using high-tech devices over other AAC devices in educational and instructional settings with children with ASD, as previously discussed. High-tech AAC devices do, however, have several limitations. First, some prior technical competence in device operation and set-up is required. Most users can, however, obtain a level of proficiency suiting their needs and, with access to online tutorials and in-app demonstrations; expertise with such devices is improving all the time. Second, there is the possibility of disrupted communication due to device damage (accumulated wear and tear, or accidents such as dropping, water damage, etc.) or simply running out of battery power. However, the availability of near-indestructible cases for portable high-tech AAC devices (e.g., LifeProof® cases) and wireless recharging devices have helped mitigate this potential limitation.

3.1. Future research and limitations of current review

Our findings indicate there is a need for further empirical research implementing high-tech devices across a range of different skills (academic, social skills, etc.) with children with autism. We have shown that there is relative a dearth of evidence supporting facilitative effects of high-tech devices such as iPad®-based applications with skills such as requesting information, distance and persistence and using sentences with children with ASD. Indeed, Kagohara et al. (2013) argue that the devices in the articles they reviewed were used primarily to deliver prompts (e.g., video modelling) or to teach users to request preferred items. This indicates a need for caution with the applied use of AAC devices because research has tended to focus on basic requesting skills. It follows then that the use of such devices for other communicative purposes (e.g., commenting and conversation) or more complex requesting behaviour (such as requesting information) should be an important consideration for future research. This also raises the question: what stimulus prompts might work best to teach children within the apps themselves (with no external response prompts)? There is research suggesting the limited efficacy of some forms of stimulus prompts (Green, 2001) but, to our knowledge, no study to date has utilised the high-tech options currently available. The prompting and prompt-fading literature indicates that errors are reduced and frustration minimised when feedback to increase future correct responding (e.g., "that's right", or "try again") is gradually faded (e.g., MacDuff, Krantz, & McClannahan, 2001). The development of further high-tech apps and devices would do well to consider incorporating such stimulus control protocols.

One of the aims of the current review was to examine the efficacy of studies aimed at teaching requesting skills. It is possible however that a publication bias may exist where papers describing successful outcomes are more likely to get published than those describing negative findings. If such a bias is present, then the current review only provides a partial picture of the role of high-tech AAC devices in communication research with children with ASD.

In conclusion, our systematic review of high-tech AAC devices to facilitate requesting in children with ASD has shown that SGDs were most commonly employed to request preferred items or food with a relatively small number of target skills. Further research is needed to evaluate the claims made about high-tech AAC devices in the treatment of language deficits specifically and problematic behaviour generally. Moreover, given the proliferation of high-tech AAC devices relative to the dearth of studies evaluating their efficacy, it will be important to undertake regular reviews of the literature and formally evaluate (e.g., via meta-analysis) their role in helping non-vocal children with ASD to gain functional communicative independence and access the "world of wants and needs".

Acknowledgements

Manuscript preparation was supported by a grant from Autism Speaks (#8049).

References

American Psychiatric Association (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Washington, DC: American Psychiatric Association.

American Speech-Language-Hearing Association (1989). Competencies for speech-language pathologists providing services in augmentative communication. *ASHA, 31*, 107–110.

Boesch, M. C., Wendt, O., Subramanian, A., & Hsu, N. (2013). Comparative efficacy of the Picture Exchange Communication System (PECS) versus a speech-generating device: Effects on social-communicative skills and speech development. *Augmentative and Alternative Communication, 29*(3), 197–209.

Bondy, A. S., & Frost, L. A. (1994). The picture exchange communication system. *Focus on Autism and Other Developmental Disabilities, 9*(3), 1–19.

Bzoch, K. R., & League, R. (1991). *Receptive-Expressive Emergent Language Scale* (2nd ed.). Austin, TX: Pro-Ed.

Carr, E. G., & Dores, P. A. (1981). Patterns of language acquisition following simultaneous communication with autistic children. *Analysis and Intervention in Developmental Disabilities, 1*, 347–361.

Chambers, M., & Rehfeldt, R. A. (2003). Assessing the acquisition and generalization of two mand forms with adults with severe developmental disabilities. *Research in Developmental Disabilities, 24*(4), 265–280.
Charlop, M. H., & Haymes, L. K. (1994). Speech and language acquisition and intervention: Behavioral approaches. In J. L. Matson (Ed.), *Autism in children and adults: Etiology, assessment and intervention* (pp. 140–213). Pacific Grove, CA: Brooks/Cole.
Charlop-Christy, M. H., Carpenter, M., Le, L., LeBlanc, L. A., & Kellet, K. (2002). Using the picture exchange communication system (PECS) with children with autism: Assessment of PECS acquisition, speech, social-communicative behavior, and problem behavior. *Journal of Applied Behavior Analysis, 35*(3), 213–231.
Choi, H., O'Reilly, M., Sigafoos, J., & Lancioni, G. (2010). Teaching requesting and rejecting sequences to four children with developmental disabilities using augmentative and alternative communication. *Research in Developmental Disabilities, 31*(2), 560–567.
Christ, T. J. (2007). Experimental control and threats to internal validity of concurrent and nonconcurrent multiple-baseline designs. *Psychology in the Schools, 44*, 451–459.
Common Sense Media, & Rideout, V. (2013). *Zero to eight: Children's media use in America*. Common Sense Media Retrieved from: http://www.commonsensemedia.org/research. Last accessed 05.03.14.
De Leo, G., Gonzales, C. H., Battagiri, P., & Leroy, G. (2011). A smart-phone application and a companion website for the improvement of the communication skills of children with autism: Clinical rationale, technical development and preliminary results. *Journal of Medical Systems, 35*(4), 703–711.
DeLeon, I. G., & Iwata, B. A. (1996). Evaluation of a multiple-stimulus presentation format for assessing reinforcer preferences. *Journal of Applied Behavior Analysis, 29*, 519–532.
Dixon, M. R., Small, S. L., & Rosales, R. (2007). Extended analysis of empirical citations with Skinner's *Verbal Behavior*: 1984–2004. *The Behavior Analyst, 30*, 197–209.
Duker, P., Didden, R., & Sigafoos, J. (2004). *One to one training: Instructional procedures for learners with developmental disabilities*. Austin, TX: Pro-Ed.
Durand, V. M. (1999). Functional communication training using assistive devices: Recruiting natural communities of reinforcement. *Journal of Applied Behavior Analysis, 32*(3), 247–267.
Dymond, S., O'Hora, D., Whelan, R., & O'Donovan, A. (2006). Citation analysis of Skinner's *Verbal Behavior*: 1984–2004. *The Behavior Analyst, 29*, 75–88.
Fenson, L., Marchman, V. A., Thal, D., Dale, P. S., Bates, E., & Reznick, J. S. (2007). *The MacArthur-Bates Communicative Development Inventories user's guide and technical manual* (2nd ed.). Baltimore, MD: Brookes.
Flores, M., Musgrove, M., Renner, S., Hinton, V., Strozier, S., Franklin, S., et al. (2012). A comparison of communication using the Apple iPad and a picture-based system. *Augmentative and Alternative Communication, 28*(2), 74–84.
Frost, L., & Bondy, A. (2002). *The Picture Exchange Communication System (PECS) Training Manual* (2nd ed.). Newark, DE: Pyramid Products Inc.
Gersten, R., Fuchs, L. S., Compton, D., Coyne, M., Greenwood, C., & Innocenti, M. S. (2005). Quality indicators for group experimental research and quasi-experimental research in special education. *Exceptional Children, 71*, 149–164.
Green, G. (1996). Evaluating claims about treatments for autism. In C. Maurice, G. Green, & S. C. Luce (Eds.), *Behavioral Intervention for Autism: A Manual for Parents and Professionals* (pp. 15–44). Austin, Texas: Pro-Ed.
Green, G. (2001). Behavior analytic instruction for learners with autism advances in stimulus control technology. *Focus on Autism and Other Developmental Disabilities, 16*(2), 72–85.
Green, D., Charman, T., Pickles, A., Chandler, S., Loucas, T., Simonoff, E., et al. (2009). Impairment in movement skills of children with autistic spectrum disorders. *Developmental Medicine & Child Neurology, 51*(4), 311–316.
Green, V., Sigafoos, J., Didden, R., O'Reilly, M., Lancioni, G., Ollington, N., et al. (2008). Validity of a structured interview protocol for assessing children's preferences. In P. Grotewell & Y. Burton (Eds.), *Early childhood education: Issues and developments* (pp. 87–103). New York: Nova Science Publishers.
Hammill, D. D., & Newcomer, P. L. (2008a). *Test of language development-intermediate* (4th ed.). San Antonio, TX: Pearson.
Hammill, D. D., & Newcomer, P. L. (2008b). *Test of language development-primary* (4th ed.). San Antonio, TX: Pearson.
Harrison, P., & Oakland, T. (2003). *Adaptive Behavior Assessment System (ABAS-II)*. San Antonio, TX: The Psychological Corporation.
Hayes, G. R., Hirano, S., Marcu, G., Monibi, M., Nguyen, D. H., & Yeganyan, M. (2010). Interactive visual supports for children with Autism. *Personal and Ubiquitous Computing, 14*, 663–680.
Horner, R. D., & Baer, D. M. (1978). Multiple-probe technique: A variation of the multiple baseline. *Journal of Applied Behavior Analysis, 11*(1), 189–196.
Horner, R. H., Carr, E. G., Halle, J., McGee, G., Odom, S., & Wolery, M. (2005). The use of single-subject research to identify evidence-based practice in special education. *Exceptional Children, 71*, 165–178.
Kagohara, D. M., van der Meer, L., Ramdoss, S., O'Reilly, M. F., Lancioni, G. E., Davis, T. N., et al. (2013). Using iPods® and iPads® in teaching programs for individuals with developmental disabilities: A systematic review. *Research in Developmental Disabilities, 34*(1), 147–156.
Kennedy, C. H. (2005). *Single-case designs for educational research*. Pearson.
Klinger, L., Dawson, G., & Renner, P. (2002). Autistic disorder. In E. Mash & R. Barkley (Eds.), *Child psychopathology* (pp. 409–454). New York: Guilford Press.
Knight, V., McKissick, B. R., & Saunders, A. (2013). A review of technology-based interventions to teach academic skills to students with autism spectrum disorder. *Journal of Autism and Developmental Disorders, 41*, 1–21.
Lancioni, G. A., O'Reilly, M. F., Cuvo, A. J., Singh, N. N., Sigafoos, J., & Didden, D. (2007). PECS and VOCAs to enable students with developmental disabilities to make requests: An overview of the literature. *Research in Developmental Disabilities, 28*, 468–488.
LeBlanc, L. A., Dillon, C. M., & Sauter, R. A. (2009). Establishing mand and tact repertoires. In R. A. Rehfeldt & Y. Barnes-Holmes (Eds.), *Derived relational responding: Applications for learners with autism and other developmental disabilities* (pp. 79–110). Oakland, CA: New Harbinger.
Leroy, G., & De Leo, G. (2008). Communication software for children with autism and their caregivers. *Autism News of Orange County and the Rest of the World, 5*(1), 15.
MacDuff, G. S., Krantz, P. J., & McClannahan, L. E. (2001). Prompts and prompt-fading strategies for people with autism. In C. Maurice, G. Green, & R. M. Foxx (Eds.), *Making a difference: Behavioral intervention for autism* (pp. 37–50). Austin, TX: PRO-ED.
Magiati, I., & Howlin, P. (2003). A pilot evaluation study of the Picture Exchange Communication System (PECS) for children with autistic spectrum disorders. *Autism, 7*(3), 297–320.
May, R. J., & Dymond, S. (2014). Facilitating emergent verbal repertoires in individuals with autism and other developmental disorders: Insights from behaviour analysis. In J. Arciuli & J. Brock (Eds.), *Trends in Language Acquisition Research: Language and Communication Impairment in Childhood Autism*. Amsterdam: John Benjamins.
Mirenda, P. (2003). Toward functional augmentative and alternative communication for students with autism: Manual signs, graphic symbols, and voice output communication aids. *Language, Speech, and Hearing Services in Schools, 34*(3), 203.
Mirenda, P., & Iacono, T. (2009). *Autism spectrum disorders and AAC*. Baltimore: Paul H Brookes.
Murray, J., & Goldbart, J. (2009). Cognitive and language acquisition in typical and aided language learning: A review of recent evidence from an aided communication perspective. *Child Language Teaching and Therapy, 25*(1), 31–58.
National Autism Center (2008). *National Standards Project*. Randolf, MA: Author Retrieved from: www.nationalautismcenter.org/about/national.php. Last accessed 05.03.14.
Nunes, D. R. P. (2008). AAC intervention for autism: A research summary. *International Journal of Special Education, 23*(2), 17–26.
Olive, M. L., de la Cruz, B., Davis, T. N., Chan, J. M., Lang, R. B., O'Reilly, M. F., et al. (2007). The effects of enhanced milieu teaching and a voice output communication aid on the requesting of three children with autism. *Journal of Autism and Developmental Disorders, 37*(8), 1505–1513.
Olive, M. L., Lang, R. B., & Davis, T. N. (2008). An analysis of the effects of functional communication and a voice output communication aid for a child with autism spectrum disorder. *Research in Autism Spectrum Disorders, 2*(2), 223–236.
Pace, G. M., Ivancic, M. T., Edwards, G. L., Iwata, B. A., & Page, T. J. (1985). Assessment of stimulus preference and reinforcer value with profoundly retarded individuals. *Journal of Applied Behavior Analysis, 18*(3), 249–255.
Rehfeldt, R. A., & Root, S. L. (2005). Establishing derived requesting skills in adults with severe developmental disabilities. *Journal of Applied Behavior Analysis, 38*(1), 101–105.

Rivera, J., & van der Meulen, R. (2014). *Gartner Says Worldwide Tablet Sales Grew 68 Percent in 2013, With Android Capturing 62 Percent of the Market*. Retrieved from: http://www.gartner.com/newsroom/id/2674215. Last accessed 05.03.14.
Rosales, R., & Rehfeldt, R. A. (2007). Contriving transitive conditioned establishing operations to establish derived manding skills in adults with severe developmental disabilities. *Journal of Applied Behavior Analysis, 40*, 105–121.
Rosales, R., Stone, K., & Rehfeldt, R. A. (2009). The effects of behavioral skills training on implementation of the picture exchange communication system. *Journal of Applied Behavior Analysis, 42*(3), 541–549.
Rotholz, D. A. (1989). Functionality of two modes of communication in the community by students with developmental disabilities: A comparison of signing and communication books. *Journal of the Association for Persons with Severe Handicaps, 14*(3), 227–233.
Sautter, R. A., & LeBlanc, L. A. (2006). Empirical applications of Skinner's analysis of verbal behavior with humans. *The Analysis of Verbal Behavior, 22*(1), 35.
Schepis, M. M., Reid, D. H., Behrmann, M. M., & Sutton, K. A. (1998). Increasing communicative interactions of young children with autism using a voice output communication aid and naturalistic teaching. *Journal of Applied Behavior Analysis, 31*(4), 561–578.
Schlosser, R., & Lee, D. (2000). Promoting generalization and maintenance in augmentative and alternative communication: A meta-analysis of 20 years of effectiveness research. *Augmentative and Alternative Communication, 16*(4), 208–226.
Schlosser, R. W., Sigafoos, J., Luiselli, J. K., Angermeier, K., Harasymowyz, U., Schooley, K., et al. (2007). Effects of synthetic speech output on requesting and natural speech production in children with autism: A preliminary study. *Research in Autism Spectrum Disorders, 1*(2), 139–163.
Schlosser, R. W., & Wendt, O. (2008). Effects of augmentative and alternative communication intervention on speech production in children with autism: A systematic review. *American Journal of Speech-Language Pathology, 17*(3), 212.
Schreibman, L. (2000). Intensive behavioral/psychoeducational treatments for autism: Research needs and future directions. *Journal of Autism and Developmental Disorders, 30*(5), 373–378.
Schwartz, I. S., Garfinkle, A. N., & Bauer, J. (1998). The picture exchange communication system communicative outcomes for young children with disabilities. *Topics in Early Childhood Special Education, 18*(3), 144–159.
Sennott, S., & Bowker, A. (2009). Autism, AAC, and Proloquo2Go. *Perspectives on Augmentative and Alternative Communication, 18*, 137–145.
Shane, H., Laubscher, E., Schlosser, R., Flynn, S., Sorce, J., & Abramson, J. (2012). Applying technology to visually support language and communication in individuals with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 42*, 1228–1235.
Sigafoos, J., Didden, R., & O'Reilly, M. (2003). Effects of speech output on maintenance of requesting and frequency of vocalizations in three children with developmental disabilities. *Augmentative and Alternative Communication, 19*(1), 37–47.
Sigafoos, J., & Meikle, B. (1996). Functional communication training for the treatment of multiply determined challenging behavior in two boys with autism. *Behavior Modification, 20*(1), 60–84.
Sigafoos, J., O'Reilly, M., Ganz, J. B., Lancioni, G. E., & Schlosser, R. W. (2005). Supporting self-determination in AAC interventions by assessing preference for communication devices. *Technology and Disability, 17*(3), 143–153.
Sigafoos, J., O'Reilly, M. F., Seely-York, S., Weru, J., Son, S. H., Green, V. A., et al. (2004). Transferring AAC intervention to the home. *Disability & Rehabilitation, 26*(21–22), 1330–1334.
Sigafoos, J., & Reichle, J. (1992). Comparing explicit to generalized requesting in an augmentative communication mode. *Journal of Developmental and Physical Disabilities, 4*, 167–188.
Skinner, B. F. (1957). *Verbal behavior*. New York: Appleton-Century-Crofts.
Son, S. H., Sigafoos, J., O'Reilly, M., & Lancioni, G. E. (2006). Comparing two types of augmentative and alternative communication systems for children with autism. *Developmental Neurorehabilitation, 9*(4), 389–395.
Sparrow, S., Balla, D., & Cicchetti, D. (1984). *Vineland adaptive behaviour scale*. Circle Pines, MN: American Guidance Service.
Sparrow, S., Balla, D., & Cicchetti, D. (2003). *Vineland-Z adaptive behavior scales (Dutch ed.)*. Leiden: PITS.
Sparrow, S. S., Balla, D. A., Cicchetti, D. V., & Doll, E. A. (1985). *Vineland adaptive behavior scales*. Circle Pines, MN: American Guidance Service.
Sparrow, S. S., Cicchetti, V. D., & Balla, A. D. (2005). *Vineland adaptive behavior scales* (2nd ed.). Circle Pines, MN: American Guidance Service.
Stafford, M. W., Sundberg, M. L., & Braam, S. (1988). A preliminary investigation of the consequences that define the mand and the tact. *The Analysis of Verbal Behavior, 6*, 61–71.
Sundberg, M. L., & Michael, J. (2001). The benefits of Skinner's analysis of verbal behavior for children with autism. *Behavior Modification, 25*(5), 698–724.
Tincani, M. (2004). Comparing the picture exchange communication system and sign language training for children with autism. *Focus on Autism and Other Developmental Disabilities, 19*(3), 152–163.
Trembath, D., Balandin, S., & Togher, L. (2007). Vocabulary selection for Australian children who use augmentative and alternative communication. *Journal of Intellectual and Developmental Disability, 32*, 291–301.
Trembath, D., Balandin, S., Togher, L., & Stancliffe, R. J. (2009). Peer-mediated teaching and augmentative and alternative communication for preschool-aged children with autism. *Journal of Intellectual and Developmental Disability, 34*(2), 173–186.
van der Meer, L., Didden, R., Sutherland, D., O'Reilly, M. F., Lancioni, G. E., & Sigafoos, J. (2012). Comparing three augmentative and alternative communication modes for children with developmental disabilities. *Journal of Developmental and Physical Disabilities, 24*(5), 451–468.
van der Meer, L., Kagohara, D., Achmadi, D., O'Reilly, M. F., Lancioni, G. E., Sutherland, D., et al. (2012). Speech-generating devices versus manual signing for children with developmental disabilities. *Research in Developmental Disabilities, 33*(5), 1658–1669.
van der Meer, L., Kagohara, D., Roche, L., Sutherland, D., Balandin, S., Green, V. A., et al. (2013). Teaching multi-step requesting and social communication to two children with autism spectrum disorders with three AAC options. *Augmentative and Alternative Communication, 29*(3), 222–234.
van der Meer, L. A., & Rispoli, M. (2010). Communication interventions involving speech-generating devices for children with autism: A review of the literature. *Developmental Neurorehabilitation, 13*(4), 294–306.
Wade, W. (2013). *AppsForAAC [List of all iPhone, iPod, and iPad based AAC devices]*. Retrieved from: http://appsforaac.net/applistnoimage?items_per_page=All. Last accessed 05.03.14.