

Umbrella Review of Psychosocial Interventions Mediated through Assistive Technology
for Children with Autism Spectrum Disorder

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Abstract

Aim: In the past 20 years, a large body of autism spectrum disorder (ASD) intervention research has emerged. In addition, the number of systematic reviews (SRs) aimed at synthesizing that body of research has grown substantially. The present umbrella review collates information from multiple SRs of psychosocial interventions mediated through assistive technologies for children with ASD to 1) determine the quality of these reviews and 2) to determine best practice recommendations for assistive technology-mediated intervention in an applied setting.

Method: SRs were identified through comprehensive searches of six electronic databases. Eligible studies met the following criteria: 1) publication date between 2006 and 2016; 2) description of systematic search procedures; 3) participants aged 0-12 with a diagnosis of ASD; 4) review of psychosocial intervention mediated through assistive technology, and 5) outcomes relevant to the core domains of ASD. The methodological quality of SRs was assessed using the *Assessment of Methodological Quality of Systematic Reviews* (AMSTAR) (Shea et al., 2007; Shea et al., 2009) and descriptive data were extracted.

Results: Thirty-eight SRs of psychosocial ASD interventions mediated through assistive technology met the inclusion criteria. The interventions were divided into seven categories: video modeling (VM), Picture Exchange Communication System (PECS), augmentative and alternative communication (AAC), activity schedules, social robotics, computer based interventions (CBI), and ‘other’ tech-mediated interventions. The included reviews demonstrated varying degrees of methodological quality, but were overall low. Generally, results indicated positive effects of tech-mediated interventions on multiple outcomes related to the core domains of deficit for ASD.

Interpretation: The findings of this umbrella review confirm that there has been an explosion of SRs focused on psychosocial ASD interventions. The SRs of tech-mediated interventions described positive effects, indicating promise for improving outcomes related to the core domains of symptoms for ASD. The findings are subject to bias due to the relatively weak SR methodological quality. Future SRs of high methodological quality synthesizing high quality primary studies will be required to confirm the positive effects of tech-mediated interventions for ASD.

Keywords: autism, intervention, social communication, behavior, assistive technology

Preface

The research conducted for this thesis was supervised by Dr. Veronica Smith at the University of Alberta and involved the collaborative efforts of several other individuals. Under the direction of Dr. Smith and myself, a research librarian, Lisa Tjosvold, wrote and carried out the systematic search. A fellow graduate student at the University of Alberta, Elizabeth Gange, served as the second reviewer for the study selection procedure, the primary reviewer for the data extraction procedure, created and managed databases, and completed calculations associated with the data. Dr. Tamara Yee served as the second reviewer for the methodological quality assessment procedure. The initial concept for this study was my own and was further developed with the guidance of Dr. Smith. I served as the primary reviewer for the study selection procedure, the second reviewer for the data extraction procedure, and the primary reviewer for the methodological quality assessment procedure. I created and managed databases and completed calculations associated with the data. The following manuscript, including data analysis, interpretation, discussion, and all figures and tables are my own original work. Dr. Smith provided composition support and edits. This thesis has not been previously published.

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Introduction

The aim of systematic reviews (SRs) is to “draw together all known knowledge on a topic area” (Grant & Booth, 2009, p. 102) by conducting systematic and replicable searches, evaluations, and syntheses of the research evidence. Once synthesized, the hope is that research will inform those practices that are implemented in an applied setting. However, when the body of literature expands significantly and a vast number of SRs are being published, this becomes challenging. When there are many SRs on a particular topic an ‘umbrella review’ serves as a method for compiling and combining evidence from several SRs into one accessible and functional document (Grant & Booth, 2009).

Since autism spectrum disorder (ASD) was first described by Leo Kanner in 1943, there has been both a rising prevalence of the disorder and an explosion of research exploring effective interventions aimed at promoting optimal development for children and youth who receive the diagnosis. In the recent past, there has been a parallel increase in the number of SRs aimed at summarizing the ASD intervention literature (Seida et al., 2009). An umbrella review of psychosocial interventions for ASD may serve to narrow the divide between research and practice by synthesizing what is known, what remains unknown, guidelines for practice, and recommendations for future research. The aim of the present umbrella review is to combine the massive body of ASD intervention research rendering it accessible and manageable to a broad audience.

Specifically, this umbrella review compiles data from multiple SRs of ASD interventions that are mediated through assistive technology (AT). AT includes devices, equipment, and systems that are aimed at improving the functional competencies of individuals with disabilities (Cook & Hussey, 2002). These ATs include products and structures that can be categorized as

either low-technology (low-tech) or high-technology (high-tech). Low-tech AT interventions are those that are relatively inexpensive, simple to make, easy to obtain (e.g., communication boards, visual schedules; Cook & Hussey, 2002), and may involve mechanical components (e.g., Picture Exchange Communication System (PECS), communication books; Scherer, 1996). High-tech assistive technology devices are those that are relatively expensive, more complicated and difficult to make, harder to obtain (e.g., electronic speech generating devices (SGDs), social robotics; Cook & Hussey, 2002), and typically involve electronic components (e.g., iPad, video modeling (VM); Scherer, 1996). Some categories of AT include both low-tech and high-tech options (e.g., augmentative and alternative communication (AAC)). Early narrative reviews (e.g., Mirenda, 2001) suggested that interventions mediated through AT for children with ASD were viable options. No umbrella review of this literature has been published to date. The present review aims to fill this gap in the literature.

Autism Spectrum Disorders

Autism was first described by psychiatrist Leo Kanner in his 1943 work “Autistic Disturbances of Affective Contact”. This initial identification of autism involved what Kanner (1943) described as a powerful desire for aloneness and an obsessive insistence on sameness. Over the past 65 years while the definition has been refined somewhat, Kanner’s essential conceptualization of the condition remains the same. In the fifth edition of the Diagnostic and Statistical Manual (DSM-5; 2013), the American Psychological Association (APA) has outlined the criteria for a diagnosis of ASD. Unlike the previous edition of the DSM, the current edition collapses what used to be several distinct diagnoses (e.g., Asperger’s syndrome, pervasive developmental disorder not otherwise specified (PDD-NOS), autism) under the broad banner of ASD.

The DSM-5 criteria for an ASD diagnosis focuses around two core domains of deficit; social communication (SC) and restricted or repetitive patterns of behavior, interests, or activities (RRB). The SC domain involves persistent deficits related to 1) social-emotional reciprocity; 2) nonverbal communicative behaviors; and 3) developing, maintaining, and understanding relationships. The RRB domain involves 1) displays of stereotyped or repetitive motor movements, use of objects, or speech; 2) insistence on sameness, excessive adherence to routines, or ritualized patterns of verbal or nonverbal behavior; 3) highly restricted or fixated interests; and 4) either hyper-reactivity or hypo-reactivity to sensory input or an unusual interest in sensory aspects of the environment. The DSM-5 further stipulates that symptoms must present in the early developmental period, must limit or impair daily functioning, and cannot be better explained by intellectual disability (ID) or global developmental delay (DD).

Psychosocial Intervention for ASD

Psychosocial interventions are non-pharmacological treatments that intend to improve functional capabilities related to the core symptoms of ASD. Many different types of psychosocial interventions have been developed with this purpose. These interventions target outcomes related to SC and RRB. They also often attempt to promote development in competencies in additional outcome areas as well (e.g., daily living skills, academic skills). In the first and only previous umbrella review of psychosocial interventions for ASD, Seida et al., (2009) noted, there are broad variations among interventions in terms of their theoretical framework, the method of delivery, and comprehensiveness. Some interventions are highly prescriptive and manualized (e.g., PECS), whereas others involve the use of tools and systems that must be adapted to the specific needs and circumstances of the child in question (e.g.,

SGDs). Multiple psychosocial intervention options are available for parents, teachers, and clinicians to consider, including those mediated through AT.

Interventions Mediated through Assistive Technology

Psychosocial interventions for children with ASD can take many forms. Some interventions are delivered by highly trained professional clinicians (e.g., applied behavior analysis (ABA), cognitive behavioral therapy (CBT)), others are mediated by a social communication partner such as a parent, sibling, or peers (e.g., Social Stories, peer mediated intervention (PMI)), and others are mediated through AT. Reichle (2011) cited several benefits of implementing interventions mediated by AT. Reichle (2011) asserted that AT facilitates personal independence and increases social inclusion for its target population, and also results in other positive collateral effects (e.g., speech production, comprehension of speech, behavior).

Dividing ATs based on their being either low-tech or high-tech would be an oversimplification; some are exclusively low-tech and some are exclusively high-tech, but some offer options or both mediums. Following are descriptions of interventions mediated through AT that have been commonly used with children with ASD:

1. Video modeling (high-tech): VM involves using a video-taped model to demonstrate behavior and teach skills (Dowrick, 1991). VM “incorporate[s] two ASD effective learning modalities: visual cued instruction and modeling” (Thompson, 2014, p. 5) using a high-tech platform. SRs included in this umbrella review evaluated various forms of VM, such as video self-modeling (VSM) where the target child serves as his/her own video model and point-of-view video modeling (POV-VM) where the video is taken from the point-of-view of the target child.

2. **Augmentative and alternative communication (low-tech and high-tech):** AAC is a broad category of intervention that includes both low-tech and high-tech supports for individuals who are nonverbal or who are considered to have Complex Communication Needs (CCN). AAC can be either unaided or aided. Unaided AAC, such as sign language, involves reliance on the user's body to convey messages. Aided AAC involves reliance on tools or equipment, such as iPads or other electronic devices to communicate.
3. **Picture Exchange Communication System (low-tech):** PECS, an example of a low-tech form of aided AAC, is an exchange-based communication program designed to support the development of functional communication skills among children with ASD (Bondy & Frost, 2002). It has manualized procedures in order to promote systematic implementation and a high degree of intervention fidelity. There are six distinct phases of the PECS program through which a child progresses. The first phase involves exchanging a picture of a desired item for the actual item. The program culminates in the sixth phase where the child exchanges sentences strips in response to questions posed by a communication partner.
4. **Activity Schedules (low-tech and high-tech):** Activity schedules are visual representations (pictures, drawing, etc.) of a series of events that are used to prepare an individual for the next activity or the next step in an activity (Knight et al., 2015). Low-tech variations of activity schedules may involve laminated images of activities affixed to a schedule template with adhesives (McClannahan & Krantz, 1999). High-tech variants may be mediated through apps designed specifically for children with ASD (e.g., Pictello by AssistiveWare®). Visual

supports are considered to have many benefits for children with ASD (Johnston, Nelson, Evans, & Palazolo, 2009). Wiens (2017) suggested that visual supports are beneficial in that they are permanent, can be easily transferred between individuals and environments, allow for language processing, support preparation for transitions, reduce anxiety, and increase independence.

5. Computer based interventions (CBI; high-tech): CBIs involve using software programs on a computer platform to provide support for skill development and address outcomes related to the core symptoms of ASD. For example, a software program can be designed to promote the establishment of routine for an individual (Ramdoss, 2011). Language and communication, literacy, and social and emotional skills may also be addressed (Ramdoss, 2012).
6. Social robotics (high-tech): Social robotics is an emerging field in ASD intervention. These interventions which are beginning to be implemented for children with ASD involve the use of robots to stimulate social behaviors, to model or practice skills, to provide feedback, and to compare responses of children with ASD to robot or robot-like behavior with human behavior (Diehl, Schmitt, Villano, & Crowell, 2012).
7. Other (low-tech and high-tech): Other tech-mediated interventions that were identified included self-controlled technologies and cognitive training technologies. Self-controlled technologies refer to those tech-mediated interventions that are administered by the individual with ASD themselves, such as mobile devices, robots, and virtual reality (VR) (den Brok & Sterkenburg, 2015). Cognitive training technologies are those that make use of high-tech

platforms (e.g., VR, robotics) to improve performance of some measurable behavior for individuals with ASD (Wass & Porayska-Pomsta, 2014).

Systematic Reviews

SRs are highly structured reviews that rely heavily on prescriptive and meticulous methodology. These reviews seek to systematically search for, analyze, and synthesize all relevant evidence in response to research questions. Manuscripts describing the methodology of the SR must be sufficiently detailed so as to enable replicability of each phase of the review process (Grant & Booth, 2009). Several research groups, such as *Campbell Collaboration* and the *Cochrane Qualitative Methods Group*, have established protocols for conducting SRs in an attempt to standardize the process. Although not a quality assessment measure, guidelines such as the *Preferred Reporting Items for Systematic Reviews and Meta-Analyses* (PRISMA, 2015) are also setting standards for the conduct of quality SRs. PRISMA is an evidence-based set of criteria for SRs and meta-analyses. Researchers may register their study a priori with PRISMA or other research groups (e.g., *Campbell Collaboration*, *International Prospective Register of Systematic Reviews* (PROSPERO)) in order to have their study protocols reviewed to add credibility and reliability to the quality of their work and to put other researchers on notice that the SR is to be conducted.

In an effort to improve the methodological quality of SRs, Shea et al. (2007) and Shea et al. (2009) endeavored to operationalize the criteria for conducting SRs with the development of a measurement tool for the *Assessment of Multiple Systematic Reviews* (AMSTAR). Items from two previously developed tools (*Overview Quality Assessment Questionnaire* (OQAQ), (Shea, Dube, & Moher, 2001)) and a checklist developed by Sacks, Berrier, Reitman, Anaconda-Berk, & Chalmers (1987), plus additional items of methodological importance were combined and factor

analyzed to identify 11 components that when assessing 151 SRs had good face and content validity for measuring methodological quality of SRs.

Umbrella Reviews

Whereas SRs serve to synthesize a number of primary studies examining the same research question, umbrella reviews serve to synthesize a number of SRs with the same focus. In their exploration of various typologies of reviews, Grant and Booth (2009) describe an umbrella review as “compiling evidence from multiple reviews into one accessible and usable document” (p. 95). In research areas where we see SRs generated in greater number, the need for umbrella reviews increases (Grant & Booth, 2009). The aim of the umbrella review is to produce one succinct document that reflects the evidence accumulated by multiple studies and reviews. Grant and Booth (2009) indicated that “each umbrella review focuses on a broad condition or problem for which there are two or more potential intervention and highlights reviews that address these potential interventions and their results” (p. 103). Furthermore, Grant and Booth (2009) emphasize the strengths of the umbrella review as providing the reader with an extensive reference list, yet a concise analysis of a range of interventions. Such a synthesis provides the reader with the potential to quickly evaluate evidence-based information relevant to the question for which an answer is needed. Since a primary aim of the present review is to increase accessibility of the research concerning various psychosocial interventions for children with ASD and to analyze the results of multiple studies concerned with evaluating those interventions, an umbrella review is a suitable methodology to employ.

Purpose of Research

As the prevalence of ASD and the risks associated with it increase, so too does the number of studies examining effective intervention for the disorder. Additionally, more authors

are conducting SRs in an attempt to synthesize this growing body of research. The purpose of the present umbrella review is to collate information from multiple SRs of psychosocial interventions mediated through AT for children with ASD. In so doing, the quality of these reviews will be determined and best practice recommendations for technology-mediated intervention for ASD in an applied setting will be made.

Research Questions

This umbrella review addresses the following research questions:

1. What is the quality of systematic reviews that examine psychosocial interventions mediated through assistive technology for children with ASD?
2. Across systematic reviews, what are the best practice recommendations for assistive technology-mediated intervention that target symptoms of ASD?

Method

Study Design

The present review was designed using the PICO (+D) framework. The PICO framework was originally developed by Richardson, Wilson, Nishikawa and Hayward, (1995) as a tool used to guide the formation of purposeful research questions and efficient search strategies. In the PICO (+D) framework, P represents the patient, population, or problem in question, I represents the intervention being implemented, C represents the comparison or control, O represents the outcome(s), and D represents the design of the included studies. In the present umbrella review, the following PICO (+D) was utilized to formulate the search strategy and study selection criteria:

P – Children (ages 0-12) with ASD (diagnosed using DSM-IV or DSM-5 criteria)

I – Psychosocial interventions (mediated through assistive technology)

C – No psychosocial intervention or treatment as usual

O – Social communication or behavioural outcomes

D – Systematic reviews

Search Strategy

The umbrella review followed a prospective protocol that was developed a priori using the PICO (+D) framework. Comprehensive searches of the scientific literature were conducted by a research librarian in 24 electronic databases from January 2006 to April 2016. The search strategy consisted of keywords and medical subject headings for autism and related disorders and various psychosocial interventions. A list of the bibliographic databases searched and the details of the MEDLINE search strategy, which was adapted for all other electronic database searches (i.e., ERIC, PsychINFO, Cochrane Database of Systematic Reviews, DARE, and the HTA database), is provided in Appendix 1. In addition, manual searches of the reference lists and searches of personal collections were conducted to identify additional citations.

Study Selection

The study selection procedure followed two steps. In step one, SRs concerning psychosocial interventions for children with ASD were considered for inclusion in this umbrella review. Reviews were evaluated based on study design, population, intervention, outcomes, and language (e.g., English, German, etc.). In order to qualify as an SR, the authors must have defined and implemented a replicable search strategy and must have provided either a quantitative or qualitative analysis of the data from the primary studies. Meta-analyses and other types of reviews could have potentially satisfied these criteria. In terms of population, the

review must have included individuals with a diagnosis that would place them on the autism spectrum using either the DSM-IV or DSM-5 criteria (i.e., ASD, autism, Asperger's Syndrome, PDD-NOS, atypical autism, or ASD not-yet-diagnosed). Reviews also needed to include children between 0 and 12 years old. Included SRs did not have to involve ASD or children exclusively, but did need to allow for the extraction of data pertaining only to the population in question. The interventions examined in the included SRs had to be considered of the psychosocial variety as defined by Seida et al. (2009); of the non-pharmacological type and aimed at improving outcomes pertaining to the core impairments of ASD. Reviews that evaluated pharmacological, biological, or dietary interventions were excluded. The inclusion criteria pertaining to outcomes required that there was numerical or measurable reporting regarding results linked to one or both of the core symptom domains for ASD; SC or RRB. Results may have been analyzed statistically in the form of a meta-analysis or qualitatively in the form of a descriptive analysis. Reviews unavailable in English were excluded. From the data compiled from step one, a further set of inclusion criteria were applied in step two.

In step two, the aim was to locate only those SRs that specifically reviewed interventions for ASD that were mediated through AT; those that involved any form of either low-tech or high-tech, or combinations thereof. To identify these SRs, reviews were first categorized, where possible, by intervention types (e.g., complimentary therapies, comprehensive early interventions, interventions that involved a social communication partner, AT mediated interventions; see Figure 1). SRs that met the following criteria were then selected for inclusion in the present umbrella review: 1) reviewed interventions involving low-tech including activity schedules, PECS, and some forms AAC; or 2) reviewed interventions involving high-tech

including multiple forms of VM, some forms of AAC (e.g., SGDs), CBIs, social robotics, tablets and portable media technology, cognitive training technologies, and self-controlled technologies.

Figure 2 represents the study retrieval and selection process. Initially, all of the 993 citations that were retrieved via the electronic search were screened at the title and abstract level by two independent reviewers and coded as being either a duplicate, relevant, or not relevant. A consensus procedure was enacted to resolve any disagreements. The screening process resulted in the identification of 193 duplicate citations, 471 citations that were considered to be not relevant, and 329 citations that were considered to be relevant and worthy of further examination. Subsequently, full texts of each of the 329 SRs identified as relevant were evaluated by two independent reviewers who coded the inclusionary criteria (Appendix 2) in order to determine eligibility for inclusion in this umbrella review. Interrater agreement for the coding of the inclusionary criteria was calculated to be 94.6%. A consensus procedure involving a third reviewer was enacted to resolve any disagreements. The application of the inclusionary criteria and the consensus procedure resulted in the identification and acceptance of 160 suitable systematic reviews. This corpus of reviews was subsequently sorted according to intervention type (Figure 1) and 38 SRs pertaining to psychosocial intervention mediated through assistive technology were identified.

Quality Assessment

The methodological quality of included SRs was assessed using the AMSTAR tool (Shea et al., 2007; Shea et al., 2009). The AMSTAR was developed to evaluate the methodological quality of systematic reviews in the public health field and for general use. It consists of 11 distinct quality indicators: 1) an a priori design in the form of a published protocol; 2) duplicate and independent study selection and data extraction; 3) a comprehensive literature search; 4) the

use of publication status (grey literature) as an inclusion criteria; 5) a list of included and excluded studies; 6) characteristics of included studies; 7) assessment of the scientific quality of included studies; 8) consideration of the scientific quality in forming conclusions; 9) the use of appropriate methods to combine study findings; 10) assessment of publication bias; and 11) declaration of conflict of interest. Each indicator was coded based on criteria (described in Appendix 2) as either “yes”, “no”, or “can’t answer”. “Can’t answer” was assigned when the necessary information was either missing entirely or insufficient to make a clear determination. The tenth criteria (i.e., assessment of publication bias) was only applied to reviews conducting a meta-analysis. For reviews conducting descriptive analyses a code of “not applicable” was assigned for the tenth criteria. Each SR was coded by two independent reviewers using the AMSTAR operationalization guide developed by Kitsiou, Pare, & Jaana (2015). Disagreements were resolved using a consensus procedure involving consultation with a third reviewer. The interrater agreement for the process of methodological quality assessment using the AMSTAR was calculated to be 86.7% for this umbrella review.

Data Extraction

Extensive descriptive data pertaining to the characteristics of each review was extracted for all included articles. Patterned after the framework utilized by Seida et al. (2009), each article’s general characteristics (year, publication type, journal, country of origin, language, number of authors, author affiliation, funding source, and analysis type), clinical characteristics (age and diagnosis of participants, intervention type), methodological characteristics (search strategy, number and design of primary studies, methods for quality assessment, any language or publication restrictions), and results and conclusions (direction of results, positive outcomes, negative outcomes, and unclear outcomes) were collected using a standardized data collection

form. One reviewer independently extracted data for all included articles and a second reviewer independently extracted data for 29% of the included studies. Inter-rater agreement was calculated to be 91.9%.

Analysis and Presentation of Results

Characteristics of SRs are presented descriptively in evidence tables. Table 1 provides a broad synopsis of the 38 SRs by reporting data pertaining to the collective characteristics of the reviews and the combined populations that were involved. Table 2 provides data pertaining to characteristics related specifically to each individual SR; number of studies included, population age and diagnosis, intervention type, outcome domains reported on, and whether or not a meta-analysis was performed. Table 3 provides the total AMSTAR scores for each SR which were determined by calculating the sum of “yes” responses conferred on each review. Table 3 also reports the outcome domains and summarizes the positive, negative, and unclear outcomes for each individual review.

A mean AMSTAR score by year of publication was calculated and plotted concurrently with data pertaining to the number of systematic reviews of tech-mediated ASD interventions published annually (Figure 3). Calculations were also completed to identify the number of articles that received each total AMSTAR score (Figure 4) and to determine the average AMSTAR rating for the entire sample of reviews. In addition, the number of studies receiving a “yes” response for each individual criteria was calculated as a means of determining specific areas of methodological strength and weakness in the body of reviews as a whole (Figure 5). Graphs representative of this information were generated in order to provide a visual depiction of the data and to facilitate a descriptive analysis.

Results

Thirty-eight SRs of psychosocial interventions for children with ASD that involved mediation through AT and were selected for inclusion in this umbrella review. Of those 38 SRs, nine evaluated various forms of VM (e.g., POV-VM, VSM; Acar & Diken, 2012; Akullian, 2009; Bellini, Peter, Benner, & Hopf, 2007; Delano, 2007; Kagohara et al., 2010; Mason, Ganz, Parker, Burke, & Camargo, 2012; Mason, Davis, Boles, & Goodwyn, 2013; Shukla-Mehta, Miller, & Callahan, 2010; Thompson, 2014). Eleven SRs evaluated various forms of AAC, which sometimes included PECS (Chung, Carter, & Sisco, 2012; Costantino & Bonati, 2014; Ganz, et al., 2011; Ganz, et al., 2012b; Ganz, et al., 2014; Kent-Walsh, Murza, Malani, & Binger, 2015; Lorah, Parnell, Whitby, & Hantula, 2015; Millar, Light, & Schlosser, 2006; Raulston, et al., 2013; Schlosser & Wendt, 2008; van der Meer & Rispoli, 2010). Seven SRs specifically and exclusively evaluated the PECS intervention (Flippin, Reszka, & Watson, 2010; Ganz, Davis, Lund, Goodwyn, & Simpson, 2012a; Hart & Banda, 2010; Preston & Carter, 2009; Sulzer-Azaroff, Hoffman, Hortman, Bondy, & Frost, 2009; Tien, 2008; Tincani & Devis, 2011). Three of the reviews examined activity schedules (Banda & Grimmer, 2008; Knight, Sartini, & Spriggs, 2015; Lequia, Wilkerson, Kim, & Lyons, 2012), two examined CBIs (Ramdoss, et al., 2011; Ramdoss, Machalicek, Rispoli, Mulloy, Lang, & O'Reilly, 2012), two examined social robots (Diehl, Schmitt, Villano, & Crowell, 2012; Pennisi, et al., 2016), one examined self-controlled technologies (den Brok & Sterkenburg, 2015), and one examined cognitive training technologies (Wass & Porayska-Pomsta, 2014). Finally two of the SRs evaluated groups of various technology-mediated interventions (Aresti-Bartolome & Garcia-Zapirain, 2014; Grynszpan, Weiss, Perez-Diaz, & Gal, 2014).

Description of Systematic Reviews

Table 1 aggregates the collective characteristics of the included SRs and reports data including: publication type, authorship (i.e., country of corresponding author, median number of authors, funding), characteristics of the included population (i.e., age and diagnosis), and characteristics of the primary studies (i.e., number of primary studies included and primary study design). Of the 38 included reviews, 36 were published journal articles and two were dissertations (Akullian, 2009; Thompson, 2014). All of the reviews included children as the target population, but rarely exclusively. Most reviews reported participants by age range (e.g., 0-12 years, preschool children, elementary students). All of the reviews included participants who had been diagnosed with some form of ASD according to the DSM-IV or DSM-5 criteria, but often included participants with comorbid or other diagnoses (e.g., Down syndrome, attention deficit hyperactivity disorder (ADHD)). The number of primary studies included in the reviews ranged from 10 to 53, with the majority being between 10 and 29. The design of the primary studies varied and most reviews included primary studies with a variety of designs. As a result of the heterogeneity of the primary study designs, a quantitative synthesis of results was not possible in most cases. Fifteen reviews conducted meta-analyses (see Table 2) and the remaining 23 reviews provided some form of descriptive analysis. Specific details of each individual SR are provided in Table 2 including: publication date, the number of included primary studies, participant diagnoses and ages, intervention types, outcome domains, and whether or not a meta-analysis was performed.

The 38 included reviews were published between 2006 and 2016. Figure 6 represents data from all 160 SRs included in the larger corpus of SRs which was established in step 1 of the study selection process of the present review. The general trend appears to be an increase in

reviews of psychosocial interventions for ASD published annually over time. Figure 3 represents the number of SRs of tech-mediated ASD interventions published annually. There appears to be an increase in publication of reviews specific to psychosocial interventions mediated through AT as well. This data supports the assertion that there is a rapidly growing body of literature related to psychosocial intervention for ASD.

All of the reviews reported outcomes relating to one or both of the core symptoms of ASD; SC and RRB. Referencing the DSM-5 criteria, SC outcomes were considered to be those related to social communication and interaction, social-emotional reciprocity (e.g., initiation, interaction, joint attention), nonverbal communicative behaviors (e.g., eye contact, gesture), and relationships (e.g., imaginative play, interest in peers). RRB outcomes were those related to stereotyped or repetitive behaviors (e.g., repetitive motor movements, echolalia), rigidity and insistence on sameness (e.g., ritualized behavior, transitions, routines), restricted interests (e.g., preservative interests), and sensory issues (e.g., sensory sensitivities, sensory seeking behavior). Outcomes that could not be conclusively categorized as either SC or RRB (e.g., difficulty with social skills that potentially stem from deficits in either the SC or RRB domain; tantrum behavior that may have resulted from frustration with the inability to communicate or from the disruption to routine, etc.) were identified as being additional outcomes and were specified as such in Table 3. Outcomes such as intelligence (IQ), daily living skills, and academic skills were also coded as additional outcomes listed in Table 3.

Figure 7 depicts the outcome domains reported by the SRs. This information is also reported by study in Table 3. All SRs reported outcomes in the SC domain, eight exclusively so. SC and additional outcomes were reported in 21 reviews, outcomes in both the SC and RRB domains were reported in four reviews, and five reviews reported outcomes in the SC and RRB

domains along with additional outcomes. None of the reviews reported exclusively on outcomes in the RRB domain, on additional outcomes, or on the RRB domain combined with additional outcomes. These findings suggest that there is a strong focus on the SC outcome domain and a lesser focus on the RRB outcome domain with respect to tech-mediated interventions for ASD. Further to a strong focus on SC outcomes, additional outcomes outside of the SC and RRB domains are also prominently assessed and reported (e.g., daily living skills, academic skills, maladaptive behavior).

Methodological Quality

Table 3 reports the AMSTAR score of each SR. Kitsiou et al. (2015) suggested that AMSTAR scores be categorized as “low” (score 0 to 3), “middle” (score 4 to 7), or “upper” (score 8 to 11). Low scores were suggested to represent “major” methodological flaws, middle scores to represent “moderate” methodological flaws, and high scores to represent “minor or no methodological flaws”. The methodological quality of the included SRs was relatively poor overall. Of a maximum possible score of 11, the average score for the 38 reviews was 4.03, the very low end of the middle range (Kitsiou, 2015). 84.2% of the articles scored 5 or lower and none of the articles scored higher than 8 (see Figure 4). Between 2006 and 2016 there appears to be no improvement in the quality of the systematic reviews as measured by the AMSTAR; mean scores simply fluctuated between 3 and 5 over the 10 year period examined (see Figure 3).

Figure 5 presents the AMSTAR rating by criteria. Few reviews provided an a priori design, included studies from the grey literature, listed both included and excluded studies, determined the presence of publication bias, or declared conflicts of interest. Any one of these indicators of quality were present in less than 5% of the SRs. Methodological quality assessments were conducted in 36.8% of the reviews and considerations of methodological

quality with respect to formulating conclusions were provided in 47.4% of the reviews.

Interestingly, although fewer than half reported systematically assessing the methodological quality of each primary study, many SRs described giving consideration to methodological quality when constructing conclusions. Relative strengths of the SRs included reporting procedures of independent study selection and data extraction (52.6%), employing appropriate methods to combine findings of primary studies (65.8%), implementing a comprehensive search strategy (81.6%), and adequately describing the characteristics of included studies (97.4%).

Effectiveness of Interventions

Table 3 summarizes the outcomes of the SRs by intervention type. Practical implications are noted. Overall, across the SRs, the effectiveness of the AT mediated interventions was reported to be positive, although some reviews reported mixed or unclear findings for certain outcomes. Due consideration should be given to methodological quality when interpreting the findings and results of the reviews, particularly since most were assessed as having relatively poor methodological quality. Poor methodological quality threatens primarily the internal validity of the SRs (e.g., study selection; independence of data extraction; failure to note publication bias) and to a lesser extent external validity (e.g., specifying a priori research question and design). This likely has a negative impact on the reliability of the results (Shea et al., 2007; Shea et al., 2009).

Video modeling. Various forms of VM, such as VSM and POV-VM were included. Each of these various types of VM involve using video as the medium for a psychosocial intervention aimed at improving skills and behaviors related to the core domains of deficit in ASD. The VM reviews incorporated in this umbrella review included outcomes related to the SC and RRB domains, as well as other additional outcomes (e.g., functional skills, daily life

skills, academic skills). Examples of specific outcomes evaluated include behavioral functioning, communication skills, language skills, social skills, functional skills, and daily living skills. Each of the reviews reported on various combinations of outcomes (see Table 3).

The quality of the reviews related to VM were generally low, with a mean AMSTAR score of 3.3 and a range of 0 to 8. Thompson's (2014) meta-analysis was the highest scoring of the VM reviews, lending credibility and reliability to the results. Thompson (2014) concluded that VM met the criteria for an EBP (Horner et al., 2005)¹ for improving SC and behavioral outcomes in children and adolescents with ASD. Specifically, Thompson (2014) noted positive effects related to social skills, communication skills, and behavioral functioning. Strongest effects were for nonverbal participants. With an AMSTAR score of 6, Mason et al.'s (2013) meta-analysis of single case research designed studies, which specifically targeted POV-VM, made use of improvement rate difference (IRD) calculations to determine effect sizes. IRD has been defined by the *Cochrane Collaboration* (as cited in Parker, Vannest, & Brown, 2009, p. 138) as the improvement rate (IR) of the treatment phases minus the IR of the baseline phases.

¹ Horner et al. (2005) outlined five standards to apply to bodies of single-subject research when determining whether a given intervention can be considered to be an EBP. These standards include: 1) an operational definition of the practice; 2) a definition of the context in which the practice is to be implemented; 3) fidelity of implementation; 4) a practice which is functionally related to change in dependent measures as documented by single-subject research; and 5) experimental effects that have been replicated across studies (a minimum of five), researchers (a minimum of three), and participants (a minimum of twenty).

Based on benchmarks established by Parker, et al. (2009), Mason et al.'s (2013) calculations of an IRD of 0.81 for participants with ASD suggest an overall large effect size for this population. They also identified moderate positive effects for social-communication skills and play outcomes and large effects for outcomes related to independent living. Preschool and elementary aged children yielded lower effects of POV-VM overall than secondary and post-secondary participants. Mason et al.'s (2012) meta-analysis of single case research designed studies that evaluated VM, specifically where another individual served as the model, resulted in an IRD of 0.83 for participants with ASD. According to the IRD benchmarks (Parker et al., 2009), this score suggests that VM is highly effective. However, the methodological quality of the 2012 meta-analysis was determined to be three points lower on the AMSTAR scale than the 2013 meta-analysis. The 2012 meta-analysis failed to meet the AMSTAR criteria for a quality search and also failed to evaluate the methodological quality of the included primary studies and consider their quality in formulating conclusions. Therefore, the 2012 meta-analysis has a decreased reliability of results compared to the 2013 meta-analysis.

None of the reviews reported negative results, and although Shukla-Mehta et al. (2010) reported positive effects for SC responses and decreases in problem and repetitive behavior, they ultimately determined that no conclusions regarding the efficacy of VM could be made since none of the primary studies included in their review employed VM techniques in isolation, but rather in conjunction with other components (e.g., prompting, reinforcers). The remaining reviews all reported positive results for VM in various outcome domains. The overall finding of this umbrella review is that VM produces positive effects in the core domains of deficit for children with ASD.

Augmentative and alternative communication. Multiple forms of AAC were evaluated by the reviews (e.g., manual sign, communication boards/books, PECS, tablets, portable media). Each of these systems involve the use of AAC as an intervention for improving SC outcomes; all eleven AAC reviews involved SC outcomes, indicating a strong focus specifically on the SC domain. Among the SC domain, examples of specific outcomes targeted included joint attention, engagement, initiation, reciprocity, and requesting. RRB and additional outcomes, such as decreases in challenging or aggressive behavior, were also present, yet clearly secondary. Two AAC reviews involved RRB outcomes such as reducing preservative requests or irrelevant speech (Ganz et al., 2014; van der Meer & Rispoli 2010), and six involved additional outcomes (e.g., maladaptive behavior, social skills, spelling; see Table 3). The overall determination across the SRs concerning AAC is that minimally, it has modest effects in the core domains of deficit in children with ASD.

Ganz et al. (2012b) asserted that the results of their meta-analysis, which employed the use of IRD calculations, proved large effects ($IRD = 0.99$) on behavioral outcomes (e.g., decreases in challenging/disruptive behavior) in individuals with ASD. Positive outcomes related to communication skills (e.g., verbal utterances, requests) were also observed. They further concluded that picture-based systems had smaller effects than the other interventions evaluated (e.g. SGDs). Similar results were determined by Chung et al. (2012) who evaluated mostly low-tech AAC and found the interventions to be promising for increasing peer interaction outcomes, which would fall into the SC domain. Like Ganz et al. (2012b), Chung et al. (2012) also noted decreases in maladaptive behavior. Both of these studies received AMSTAR scores of 5, indicative of moderate methodological quality in the conduct of the reviews.

A common concern expressed by some parents and clinicians is that AAC supports will inhibit speech development in nonverbal children (e.g., Beukelman, 1987; Silverman, 1995). However, Millar et al. (2006) determined that 89% of the population represented in their review demonstrated modest gains in speech. Schlosser and Wendt (2008) reported that AAC interventions do not hinder speech development and may result in modest speech production gains, yet noted that expectations regarding speech gains need to be realistic. The most recent SR of AAC was conducted by Kent-Walsh et al. (2015) who noted positive effects are more commonly seen when in addition to the AAC support, communication partners are instructed on how to communicate with the AAC user; providing training and instruction to individuals (e.g., parents, caregivers) beyond the target participant with ASD improves the outcomes for the target.

Six systematic reviews (Ganz et al., 2011; Ganz et al., 2012b; Ganz et al., 2014; Lorah et al., 2015; Schlosser & Wendt, 2008; van der Meer & Rispoli, 2010) evaluated the use of SGDs, which are classified as aided high-tech AAC. Lorah et al. (2015) determined that 93% of participants in their review developed the ability to communicate using an iPod or iPad as a SGD in the context of the study. These results should be interpreted with caution as the AMSTAR score for the study in question was relatively low (3). However, all other SRs concerned with SGDs did report positive effects related to various communication behaviors and skills (e.g., initiating, requesting, commenting, speech) leading to the conclusion that SGDs are a viable intervention for improving outcomes in the SC domain. AMSTAR scores among reviews related specifically to SGDs ranged from 3 to 8, indicating a variability in the reliability of their results.

Overall, the AMSTAR assessments conducted for the subgroup of AAC reviews revealed a higher degree of methodological quality than for any of the other subgroups of tech-mediated

interventions evaluated in this umbrella review. As a whole, the AAC reviews scored a mean of 5.3 on the AMSTAR scale with a range of scores from 3 to 8. This mean score is representative of an approximate two-point difference over any of the other subgroups of tech-mediated intervention reviews included in the present study. As such, the reliability of the findings of AAC reviews is notably greater than any of the other categories included. Since AAC reviews have reported positive outcomes and the methodological quality of those reviews is relatively strong, it can be determined that AAC is a viable intervention category for supporting improvement of outcomes in the SC domain for children with ASD.

Picture exchange communication system. PECS is considered to be a form of AAC (Beukelman et al., 2012) however, for the purposes of this review, it has been identified as a distinct subcategory of reviews apart from those that examined AAC in general. The study selection and retrieval process identified seven reviews that evaluated PECS in isolation from other interventions, therefore justifying the decision to create a separate subcategory specifically for this particular form of AAC.

The SRs of PECS studies involve outcomes in the SC and RRB domains, as well as additional outcomes relating to maladaptive behavior. However, like other AAC interventions, the primary focus of the PECS intervention is SC outcomes. All seven reviews included SC outcomes, two include RRB outcomes (Hart & Banda, 2010; Preston & Carter, 2009), and three include additional outcomes related to maladaptive behavior (Ganz et al., 2012a; Sulzer-Azaroff et al., 2009; Tien, 2008). Specific SC outcomes identified include PECS exchanges, gains in speech, interaction initiations, non-verbal manding, peer engagement, reciprocity, turn taking, and play.

The findings of all seven systematic reviews of PECS indicate that it is a promising intervention (Flippin et al., 2010, Ganz et al, 2012, Hart & Banda, 2010, Preston & Carter, 2009, Sulzer-Azaroff et al., 2009, Tien, 2008, Tincani & Devis, 2011) with several positive effects reported. However, some of the SRs contend that there is not yet sufficient conclusive evidence concerning its effectiveness to establish it as an EBP (Flippin et al., 2010, Preston & Carter, 2009). Ganz et al. (2012a) concluded that children using PECS see the greatest gains on outcomes specifically targeted by the intervention, with moderate positive effects related to functional communication skills. Ganz et al. (2012a) also noted that effects for preschool children were greater than effects for elementary children. Although PECS is not intended to target speech outcomes, several reviews did report on those effects. Flippin et al. (2010) reported that speech gains were small to negative and Hart and Banda (2010) and Sulzer-Azaroff, et al. (2009) noted that some participants experienced increases in speech. In addition, some positive effects related to maladaptive behaviors were noted by Ganz et al. (2012), Hart and Banda (2010), Preston and Carter (2009), and Sulzer-Azaroff, et al. (2009). Concerns regarding maintenance and generalization of skills acquired through PECS intervention were raised by Flippin et al. (2010) and Tincani and Devis (2011). These reviewers determined that there is limited evidence to suggest that functional communication skills developed through implementation of the PECS protocol then transferred to other settings or communication partners. The mean AMSTAR score for methodological quality of the PECS reviews was 3.6 with a range of 2 to 5. As such, the reliability of the evidence is relatively weak and results should be interpreted with the methodological quality in mind. The evidence does suggest that PECS produces positive effects in the SC domain. Outcomes related to gains in speech remain unclear.

Activity schedules. Three of the SRs examined the effects of activity schedules (Banda & Grimmert, 2008; Knight, Sartini, & Spriggs, 2015; Lequia, Machalicek, & Rispoli, 2012). The reviews support the use of activity schedules in targeting outcomes in the SC domain, as well as additional outcomes relating to maladaptive behavior, transitions, independence, on-task behavior, and latency to task. All three reviews indicated outcomes related to SC as well as the aforementioned additional outcomes. None of the reviews reported outcomes in the RRB domain.

Banda and Grimmert (2008) found activity schedules effective for improving social interactions, transitions, independence, and on-task behaviors, as well as for reducing disruptive behaviors. The SR conducted by Lequia et al. (2012) determined that activity schedules were effective in increasing social initiation and engagement, improving routine completion time, and reducing challenging behavior. It was noted that effectiveness did vary somewhat across settings and was also somewhat dependent on the severity of the ASD symptoms and the level of communicative ability. Knight et al. (2015) concluded that Visual Activity Schedules (VAS) should qualify as an EBP for teaching transitions, decreasing the number of prompts required for transitions, and improving independence, on-task behavior, and task completion.

The mean AMSTAR score for the reviews evaluating activity schedules was 3.3 with a range of 2 to 5. This represents a relatively low methodological quality and doesn't contribute to strong reliability of results. However, it should be noted that none of the reviews reported any negative results. In spite of the low methodological quality of the SRs, it is the contention of this review that activity schedules are a potentially viable intervention for producing positive effects related to multiple outcomes for children with ASD.

Computer based interventions. CBIs were addressed in two of the included reviews (Ramdoss et al., 2011, Ramdoss et al., 2012). Outcomes assessed for these interventions represented both the SC and RRB domain, as well as additional outcomes including phonological awareness and social/emotional skills. Both reviews determined that CBI produced mild positive effects on SC skills (e.g., imitation, expression, social greetings, and vocabulary) and Ramdoss et al. (2011) also noted a positive outcome in the RRB domain related to decreases in echolalia. Both of the CBI reviews were assessed a score of 5 according to the AMSTAR; a moderate level of methodological quality. Although CBI is a potentially promising practice and produced positive effects, there is a limited literature base pertaining to these interventions and there wasn't sufficient evidence to qualify it as an EBP.

Social robotics. Two systematic reviews involved the application of some form of social robotics intervention (Diehl et al., 2012, Pennisi et al., 2016). In the critical review conducted by Diehl et al. (2012), social robotics were examined in terms of their effectiveness to elicit behaviors, to model or practice skills, to provide feedback, and to compare responses of children with ASD to robot or robot-like behavior with human behavior. Diehl et al. (2012) noted an increased interaction between participants and robots. They also determined that preliminary results suggest that individuals with ASD demonstrated a preference for robot or robot-like features compared to non-robotic toys and humans and that participants responded more quickly to robotic movement than human movement. Diehl et al. (2012) recognized that a limitation of their review is that peer-reviewed research related to social robotics as an intervention for ASD is in its infancy and that current literature represents preliminary and exploratory work. Pennisi et al.'s (2016) SR concluded that results related to social robotics have thus far been positive and noted that social robotics provide an avenue for connection between therapists or researchers and

participants with ASD. It was also determined by Pennisi et al. (2016) that social robotics are most effective in a clinical setting. The outcomes targeted by interventions involving social robotics fall into both the SC and RRB domain.

Neither of the included social robotics reviews were determined to have strong methodological quality. The mean AMSTAR score was determined to be 2.5 with a range of 2 to 3. As the quality of the reviews is low and the included primary research is in its infancy, conclusions regarding the effectiveness of social robotics as a tech-mediated intervention for children with ASD should be made with caution.

Other tech-mediated interventions. Four reviews evaluated the effectiveness of other tech-mediated interventions including: self-controlled technologies, virtual reality, telehealth, and cognitive training technologies. Most of these technologies are presently emerging and evolving, yet hold varying degrees of promise in terms of their potential contribution to the improvement of outcomes for children with ASD.

The review conducted by Aresti-Bartolome and Garcia-Zaparain (2014) addressed multiple tech-mediated interventions and reported on outcomes in the SC and RRB domains. Aresti-Barolome and Garcia-Zaparain (2014) included studies involving virtual reality apps, social robotics, and telehealth systems. Their findings suggested that technology can be a valuable tool for people with ASD and those that support them. Positive outcomes related to social learning and imitation skills, as well communication and interaction were noted. Telehealth systems were found to be beneficial for both diagnosis and treatment. Although the review revealed many benefits of the various tech-mediated interventions, a concern regarding the availability of personalized tools was identified.

Grynszpan, Weiss, Perez-Diaz, and Gal (2014) generated results that confirmed the effectiveness of the various tech-mediated interventions evaluated (e.g., virtual reality and computer programs). Positive outcomes fell into the SC domain and also included additional academic outcomes such as reading, phonological awareness, and object identification. The meta-analysis revealed positive post-test differences between intervention and control groups in RCT studies.

Cognitive training technologies were assessed in the review conducted by Wass and Porayska-Pomsta (2014). This review included outcomes in the SC domain as well as additional outcomes relating to social skills and academics (e.g., literacy). The effectiveness of the interventions on the academic outcomes were unclear. Although improvements were observed in the SC domain within the intervention structure, generalization to other environments did not occur. The methodological quality of the Wass and Porayska-Pomsta (2014) reviews was relatively low with an AMSTAR score of 2. Due to the low methodological quality, the results of this review should be interpreted with particular caution.

den Brok and Sterkenburg (2015) conducted a review involving self-controlled technology. The outcomes evaluated were in the SC domain and also included additional outcomes related to daily living and cognitive skills. Review results indicated that there is evidence which suggests that self-controlled technology has positive effects on the outcomes in question. Furthermore, it was determined that gains in task performance that were achieved in the intervention phase could be maintained (with possible declines) in the follow-up phase. den Brok and Sterkenburg (2015) determined that certain technologies can be utilized to foster the development of specific skills. For example, they found that daily living skills can be taught

when mediated through video and building an understanding of the emotions of others can be learned when mediated through virtual reality.

The overall methodological quality of reviews evaluating other tech-mediated interventions was relatively poor according to AMSTAR ratings. The four included reviews received a mean score of 2.25 with a range of 1 to 4. Although there appear to be some positive effects produced by these type of emerging tech-mediated interventions, the low methodological quality of the reviews makes definitive conclusions difficult.

Discussion

Similar to other fields of interventions in special education and health care, over the past decade, there has been a large increase in the number of SRs published concerning ASD interventions. The present review analyzed the evidence provided by 38 SRs of psychosocial interventions for children with ASD mediated through various forms of AT revealing positive evidence of effective interventions. The findings highlight the range of interventions mediated through AT and identify methodological issues to consider in future SRs.

Clinical Relevance

One of the primary aims of this umbrella review was to improve the accessibility and manageability of the research concerning ASD intervention for those who do not generally interact with peer-reviewed research. The findings of the research are both relevant and applicable to parents, teachers, and clinicians who are responsible for the care, support, and education of children with ASD. Although concrete recommendations concerning the specifics of which interventions will be effective for which children cannot be made, some general recommendations are offered.

SRs evaluating AAC interventions were assessed to have the highest methodological quality among the various groups of tech-mediated interventions as a whole. These reviews indicated that AAC interventions produce at least moderate positive effects in several outcome domains. Although the SRs concerning VM interventions had relatively poor methodological quality, results showed consistently positive effects in several outcome domains. VM has proven to be a reliable tool. The PECS reviews also had relatively poor methodological quality, but did reveal positive effects related to functional communication skills. Even with a fairly large number of primary studies and SRs evaluating it, the evidence concerning PECS, although positive, is not yet definitive. There is limited information about activity schedules and the quality of reviews evaluating their effectiveness is relatively low. However, many positive effects have been observed and no negative outcomes were reported. There are several other emerging interventions that are being mediated through technology such as CBIs, social robotics, self-controlled technologies, virtual reality, telehealth, and cognitive training technologies. Most of these interventions are in their infancy and have not been thoroughly evaluated. The reviews evaluating these interventions are few in number and relatively poor in quality. The effectiveness of the interventions is inconclusive at this point.

Methodological Quality

In terms of methodological quality, this umbrella review revealed there remains much room for improvement regarding the conduct of SRs. The overall methodological quality was poor with very few reviews scoring high on the quality rating tool, the AMSTAR. Of the 38 reviews, none received the maximum possible AMSTAR score of 11; the highest score was 8, which was achieved by Thompson (2014), Kent-Walsh et al. (2015), and Schlosser and Wendt (2008). In a previous umbrella review, Seida et al. (2009) reported that reviews included in their

study “often lacked a comprehensive search strategy, reliable study selection, and assessment of the quality of primary studies” (p. 101). The SRs assessed by the present study generally proved to have implemented comprehensive search strategies (81.6%), often had appropriate study selection procedures (52.3%), and sometimes evaluated the methodological quality of the included primary studies (36.5%). This comparison suggests that the quality of SRs may be increasing relative to certain specific criteria (i.e., search strategy, study selection, quality assessment). It should be noted that in many cases it was impossible to determine whether or not authors had completed the steps necessary to receive a “yes” coding for any particular AMSTAR criteria because of their failure to clearly report their methodological procedures. For example, many studies may have implemented appropriate procedures, but their published manuscript lacked the necessary details to determine that fact (i.e., 39.8% failed to adequately describe study selection procedures and 10.9% failed to adequately describe the methodological quality assessment of the primary studies resulting in a “can’t answer” rating for the criteria in question). The quality of the SRs has the potential to increase substantially based solely on an improvement in reporting procedures for methodological behavior.

With the overall methodological quality of the included SRs, as measured by the AMSTAR, being relatively low, the overall reliability of the evidence is relatively low as well. There remains a need for an improvement in methodological quality of SRs in ASD intervention or, if certain procedures were followed, better reporting of those procedures so that others may assess quality or replicate efforts at a later date.

Examining the Findings Closer to Home

Given that the prevalence of autism spectrum disorder (ASD) continues to rise (Centre for Disease Control and Prevention (CDC), 2012) and that current trends in education are

generally moving towards a more inclusive approach (Alberta Education, 2015) a growing number of early educators, teachers and educational assistants are likely to encounter students with ASD in their early learning and care and classroom settings. Providing the evidence-based supports necessary to enable students with ASD to achieve their full academic, social, and personal potential in a school setting can be a daunting task for educators who are unlikely to have much training or experience related specifically to ASD (e.g., Barnhill, Polloway, & Sumutka, 2011; Boyd & Shaw, 2010). Furthermore, based on personal experience, teachers tend to have limited contact with peer-reviewed research and are therefore less likely to be acquainted with the most current findings related to ASD intervention and best practices in the field.

As an Inclusive Education Lead Teacher for a rural school in an Alberta school district, the findings of this umbrella review are of particular interest on a practical professional level. Working in a small rural (K-9) school poses particular challenges related to supporting students with ASD. In particular, access to specialized services is somewhat limited due simply to location. The nearest major center is approximately 125 km from the school. As such, many families are unable to regularly access the professionals and the services that are available to their urban counterparts. Most rural families who have children with ASD rely heavily, yet not solely, on the school system to support them and meet their needs. The district itself does employ some specialists (e.g., a behavior specialist, educational psychologists, speech and language pathologists, occupational therapists) who travel from school to school within the district with the mandate of supporting children and their teachers and assistants. However, due to the limited number of specialists available and the high demand for service, gaining access to supports is often challenging.

As an active teacher, it has become apparent that the knowledge of the peer-reviewed research community is rarely translated into practice in applied settings. Despite what the literature has determined to be EBPs, these strategies are often not implemented. Many teachers are unfamiliar with many ASD intervention practices (e.g., VM, AAC, PECS) and whether there is evidence to support their use or not. This is not to suggest that it is the fault of the teachers themselves, but rather that there is an underlying systemic issue that had led to a strong disconnect between the research community seeking to identify EBPs and the educational professionals tasked with implementing them. The reality is that educational professionals are highly concerned with the daily needs and operation of their classrooms, which requires the bulk of their time and attention. Accessing and synthesizing peer-reviewed research isn't a practical undertaking for individuals who have to meet so many immediate and pressing demands in their jobs. Hence the need to combine findings of primary studies in SRs and then to further combine SR findings in umbrella reviews. Should the research translate into practice, educational professionals will require practical access to synthesized findings and results.

As an Inclusive Education Lead Teacher, and the primary researcher of this umbrella review, I am able to share the findings of the present study and make generalized recommendations. As suggested by Sackett, Rosenberg, Gray, Haynes, and Richardson (1996) these recommendations are not dependently solely on the best available clinical research, but also include the integration of my own clinical expertise (e.g., education, experience, skills) and give due consideration to the values of the child and his/her family (e.g., personal preferences, concerns, expectations). Children with ASD should have access to various interventions mediated through AT. VM has proven to produce positive outcomes related to SC and other functional skills. With easy access to the technology necessary to implement VM (e.g., iPads,

iPhones), and the minimal cost and training required to do so, VM is a logical intervention to select. AAC is a broad category of interventions that should also be considered. *Speech-Language & Audiology Canada* (2015) emphasized that “communication is essential to participation in life” and that “AAC tools and strategies can play an important role in enabling individuals with limited or no speech to live independent, dignified lives, commensurate with their abilities and desires” (p. 1). The specific form of AAC chosen is dependent on several factors (e.g., specific characteristics of the child, characteristics of the environment, availability of resources) that must be evaluated, but for children with CCN, some form of AAC is a viable and recommended practice for fostering SC outcomes. PECS could be considered as a potential choice for AAC, but because it lacks definitive evidence, other forms of AAC (e.g., manual sign, SGDs) should be considered with consideration given to the particular context and circumstances of the child in question. Activity schedules are an intervention that produce positive SC effects and improve additional outcomes related to behavior. These interventions are effective and relatively simple to implement. Although the quality of the SRs concerning activity schedules needs improvement, the evidence is positive. In addition, personal experience suggests that activity schedules are a highly effective intervention and should be recommended consistently. CBIs, social robotics, and other emerging interventions mediated through AT should be implemented with caution. These interventions are generally costly and complicated to apply, and their effectiveness has yet to be confirmed. In sum, much work is needed to tackle the daunting task of bringing these research findings to educators in real world settings.

Implications for Future Research

The number of SRs being published annually continues to rise. Seida et al. (2009) noted that the “earliest systematic review... identified was published in 1996, with the numbers

increasing steadily [thereafter]” (p. 101). Seida et al.’s (2009) umbrella review included 30 SRs. The studies for the present umbrella review were drawn from a corpus of 160 SRs published over the past ten years; over five times more than the Seida et al. (2009) umbrella review, which was completed less than ten years prior. This explosion in publication of SRs appears to reflect a pressing need to appraise and summarize the many primary studies that are conducted to evaluate the effectiveness of psychosocial interventions for ASD. As was argued in the introduction of this article, the gap between the research and its use in applied settings is wide. SRs have the potential to narrow that divide, but they are now so numerous that the need for umbrella reviews, such as the present study, is also growing.

The data evaluated in the present study have revealed that there are many SRs and primary studies being conducted concerning psychosocial interventions mediated through AT for children with ASD. The included SRs provide an abundance of information regarding the various types of AT utilized and the range of outcomes that they are aiming to improve. Tech-mediated interventions tend to focus on SC outcomes and generally positive effects are observed. However, using the AMSTAR tool, the methodological quality of the SRs remains low and the need for improvements in their conduct is still apparent. The quality of conduct of the SRs needs to improve in order to increase the reliability of the reported findings. A standardized methodological quality assessment tool, such as the AMSTAR, should be adopted and consistently applied. Researchers conducting SRs would do well to identify and select a quality assessment measure prior to the commencement of their research and adhere to it throughout the duration of their project.

Many of the studies included in this review employed a number of different tools to measure a wide variety of outcomes. The tools used are generally not standardized. Therefore,

making comparisons between studies or combining the results of studies is exceedingly difficult. It would be beneficial for researchers conducting primary studies in this field to adopt common and consistent means of describing, measuring, and reporting outcomes. Systematic procedures and standardized tools could be used to measure clearly defined outcomes, ideally in naturalistic settings. A uniform reporting process among primary studies would contribute to the homogenization of the data, which would in turn lead to the ability to appropriately combine findings at the SR level, and ultimately at the level of the umbrella review. However, the present study does reveal a vast range of outcomes related to ASD and all of its complexities. Considering this vast range of outcomes and the significant variability among the ASD population and their particular contexts, it must be acknowledged that the call for standardization of outcome assessment may not be entirely possible or appropriate.

In addition, beyond evaluating rudimentary effectiveness of ASD interventions on multiple outcomes, there is a need to examine the reasons as to why certain interventions are effective while others are not. Investigations concerning the common components/ingredients of effective interventions are certainly warranted. Researchers should be attempting to identify core elements of effective interventions that are linked to theoretical explanations (i.e., learning and developmental theories). Building an understanding as to why these interventions are effective and identifying common principles or elements of effective interventions has the potential to inform refinements of existing interventions and the development of new interventions.

Although the present study has been able to present a general descriptive analysis of the effectiveness of tech-mediated interventions for ASD, there are many aspects of these interventions that have not been evaluated at the SR level and can therefore not be reported in

this umbrella review. Data relating to the accessibility or cost of the intervention was not included in the SRs. Distal effects of the interventions on family, peers, and caregivers have not been evaluated. Very few of the SRs reported on the generalizability or maintenance of the interventions outside of clinical settings. There remains much work to be done in evaluating, synthesizing, and reporting these factors in primary research. Before this can be achieved at the level of the SR, this type of data must first be collected at the level of the primary study.

Limitations

The present umbrella review has limitations that must be noted and considered. Although this review involved an a priori design, it was not formally registered with either PRISMA or PROSPERO. Some studies that had been identified for potential inclusion were eliminated simply because they could not be retrieved (e.g., there was a cost for retrieval) or were excluded because no English translation was available. Nevertheless, due to the extensive search strategy employed, it is likely that the included SRs are representative of the body of SRs that have been published. It is quite possible that there was overlap in the primary studies included in the SRs (i.e., the same primary studies contributed to multiple SRs). However, a citation analysis of the primary studies included in the SRs was not completed. A list of excluded studies has not been provided in this manuscript for practical reasons, but is available from the author upon request. A quantitative assessment of publication bias was not possible as the present review included SRs of both the meta-analytic and descriptive types. Although a qualitative analysis of publication bias may have been possible by describing differences in outcome effects in published and unpublished literature (Song, Hooper, & Loke, 2013), this assessment was not undertaken. Finally, the heterogeneity of the findings of the included SRs limited the synthesis of this umbrella review to a descriptive analysis; no quantitative synthesis was possible.

Conclusions

This umbrella review revealed the presence of evidence supportive of tech-mediated interventions for ASD, yet has also highlighted the need for further primary studies and SRs to be conducted in order to confirm these findings. In its present state, the body of evidence suggests that there are several tech-mediated psychosocial interventions for children with ASD that may result in positive effects, particularly in the SC domain. However, further investigation is warranted to determine the specifics of which interventions are best suited to which children in order to meet individual needs and target outcomes of particular concern.

Declaration of Conflicts of Interest

There are no conflicts of interest to declare. No financial support or compensation was provided for the completion of this study.

Table 1: Descriptive characteristics of systematic reviews of tech-mediated interventions for ASD (n=38)

| | |
|------------------------------------------------|-----|
| Publication type | |
| Journal Article | 36 |
| Dissertation | 2 |
| Country of corresponding author | |
| United States | 28 |
| Other | 10 |
| Median number of authors per review | 3.4 |
| Funding reported | 6 |
| Type of populations studied* | |
| Children (0-12y) | 38 |
| Adolescents (12-17y) | 35 |
| Adults (18+y) | 25 |
| Type of diagnosis studied* | |
| ASD | 26 |
| Autism | 18 |
| Asperger’s Syndrome | 4 |
| PDD-NOS | 12 |
| ≥2 diagnoses | 24 |
| Number of primary studies included | |
| 10-19 | 16 |
| 20-29 | 11 |
| 30-39 | 7 |
| 40-49 | 3 |
| 50-59 | 1 |
| Type of study designs included in the reviews* | |
| Single-subject designs | 31 |
| RCT | 3 |
| Not reported | 6 |

*Categories are not mutually exclusive. ASD, autism spectrum disorder; PDD-NOS, pervasive developmental disorder not otherwise specified; RCT, randomized controlled clinical trial;

Table 2: Characteristics of systematic reviews for tech-mediated interventions for children with ASD (n=38)

| First author, year | Studies included (N) | Population characteristics | | Intervention | Outcome domains | Meta-analysis (yes/no) |
|------------------------|----------------------|--------------------------------------------------------------|----------------------------------|------------------------------------------------------------------|-----------------|------------------------|
| | | Diagnosis | Age range | | | |
| Acar, 2012 | 31 | Autistic disorder | 2-15 years | Video modeling | SC, Other | No |
| Akullian, 2009 | 20 | ASD | 3-20 years | Video modeling | SC, RRB, Other | Yes |
| Aresti-Bartolome, 2014 | 48 | ASD, AS, severe autism, HFASD, LFASD, Parkinson's disease | 2-50 years | Various tech (virtual reality apps, telehealth, social robotics) | SC, RRB | No |
| Banda, 2008 | 13 | Autism | 3-40 years | Activity schedules | SC, Other | No |
| Bellini, 2007 | 23 | ASD | 3-21 years | Video modeling, video self-modeling | SC, Other | Yes |
| Chung, 2012 | 31 | ASD, ID, ID & ASD, ASD & significant disability | 6-22 years | AAC | SC, Other | No |
| Costantino, 2014 | 14 | Disabilities | 1.5-16 years | AAC | SC, Other | No |
| Delano, 2007 | 19 | Autism | 3-20 years | Video Modeling | SC, RRB, Other | No |
| Den Brok, 2015 | 28 | ASD, ID, ASD + ID | 1-70 years | Self-controlled technology | SC, Other | No |
| Diehl, 2012 | 15 | ASD, typically developing, autism, HFASD | 1-30+ years | Robots | SC, RRB | No |
| Flippin, 2010 | 11 | Autism, ASD, PDD-NOS | 3-11 years | PECS | SC | Yes |
| Ganz, 2011 | 24 | Autism, PDD-NOS, DD, visual impairments, hearing impairments | Preschool, elementary, secondary | AAC | SC, RRB, Other | Yes |

| | | | | | | |
|-------------------|----|------------------------------------------------------------------------------------------------------------------|----------------------------------|----------------------------------|----------------|-----|
| Ganz, 2012 (AAC1) | 24 | Autism, PDD-NOS, DD, visual impairment | 3-40 years | AAC | SC, RRB, Other | Yes |
| Ganz, 2012 (PECS) | 11 | ASD, ID, visual impairments | 3-17 years | PECS | SC, RRB, Other | Yes |
| Ganz, 2014 | 35 | ASD, ID, sensory impairment | Preschool, elementary, secondary | AAC, SGD, PECS | SC, RRB, Other | Yes |
| Grynszpan, 2014 | 21 | ASD | Mean ages 3-30 years | Various tech-based interventions | SC, Other | Yes |
| Hart, 2010 | 13 | Autism, autism + MR, PDD-NOS, PDD-NOS + MR, DD, MR, MR + cerebral palsy, MR + Down syndrome | 3-40 years | PECS | SC, RRB | Yes |
| Kagohara, 2010 | 44 | ASD (autism, AS, HFASD, PDD-NOS) | 2-19 years | Video-based instructions | SC, Other | No |
| Kent-Walsh, 2015 | 17 | ASD, ID/DD, cerebral palsy, other | 2.5-26 years | AAC with partner | SC | Yes |
| Knight, 2015 | 31 | ASD | 3-22 years | Visual activity schedules | SC, RRB | No |
| Lequia, 2012 | 18 | Autistic-like characteristics + Landeau-Lleffner syndrome, AS, ASD, ID, HFASD, PDD-NOS, ASD + ADHD | 3-14 years | Activity schedules | SC, RRB | No |
| Lorah, 2015 | 17 | ASD, ODD, ADHD, ID, multiple disabilities, Down syndrome, congenital myotonic dystrophy, Angelman, DD | 3-23 years | Tablets, portable media, SGD | SC | No |
| Mason, 2012 | 42 | ASD, DD, comorbid disorders (speech impairment, epilepsy, LD, Tourette's, visual impairment, EBD, mood disorder) | 2-18+ years | Video modeling | SC, RRB, Other | Yes |

| | | | | | | |
|-----------------------|----|----------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|------------------------------|-----------|-----|
| Mason, 2013 | 14 | ASD, DD | 2-18+ years | Point-of-view video modeling | SC, Other | Yes |
| Millar, 2006 | 23 | Autism, MR, Down syndrome, DD | 2-60 years | AAC | SC | Yes |
| Pennisi, 2016 | 36 | ASD | 3-21 years | Social robotics | SC, RRB | No |
| Preston, 2009 | 27 | PDD-NOS, autism, "autistic characteristics," ASD | 2-34 years | PECS | SC, RRB | No |
| Ramdoss, 2011 | 10 | Autism | 3-14 years | Computer-based interventions | SC | No |
| Ramdoss, 2012 | 11 | AS, ASD, HFASD, autism, Down syndrome, typically developing | 4-52 years | Computer-based interventions | SC | No |
| Raulston, 2013 | 21 | Autism, autism + cerebral palsy, PDD-NOS, ASD | 2-25 years | AAC, PECS, other | SC | No |
| Schlosser, 2008 (AAC) | 11 | Autism, PDD-NOS | 3-12 years | AAC, PECS, SGD | SC | No |
| Shukla-Mehta, 2010 | 26 | ASD | 3-13 years | Video instruction | SC, RRB | No |
| Sulzer-Azaroff, 2009 | 34 | PDD-NOS, cerebral palsy, ASD, DD, ID, Down syndrome, ODD, LD, blind, profound hearing loss, ADHD, MR | 1.5-58 years | PECS | SC | No |
| Thompson, 2014 | 35 | ASD | 3-18 years | Video modeling | SC, RRB | Yes |
| Tien, 2008 | 13 | PDD, ADHD, autism, DD with autistic characteristics, DD and speech/language impairment, severe LD, other DD | 1-12 years | PECS | SC | No |
| Tincani, 2011 | 16 | Autism, DD, Down syndrome + autistic features, MR + expressive + receptive language disorder, MR + cerebral palsy + seizure disorder, Down syndrome + MR | Preschool - adult | PECS | SC | Yes |

| | | | | | | |
|--------------------|----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|---------------------------------|----------------|----|
| | | + seizure disorder, MR, autism + aphasia + global developmental delay + ADHD, global developmental delay + seizure disorder, blindness, cognitive impairment, PDD-NOS + MR, cerebral palsy + seizure disorder, multiple disabilities | | | | |
| Van Der Meer, 2010 | 23 | ASD | 3-16 years | SGD | SC | No |
| Wass, 2014 | 53 | ASD | 4-40 years | Cognitive training technologies | SC, RRB, Other | No |

*ASD, autism spectrum disorder; AS, Asperger syndrome; HFASD, high functioning autism spectrum disorder; LFASD, low functioning autism spectrum disorder; PDD-NOS, pervasive developmental disorder not otherwise specified; ID, intellectual disability; DD, developmental disability; MR, mental retardation; ADHD, attention deficit hyperactivity disorder; ODD, oppositional defiant disorder; LD, learning disability; EBD, emotional behavioural disorder; AAC, augmentative and alternative communication; PECS, picture exchange communication system; SGD, speech generating device; SC, social communication; RRB, restrictive or repetitive behavior.

Table 3: Results of systematic reviews for tech-mediated interventions for children with ASD (n=38)

| Video Modeling (VM) | | | |
|----------------------------|---------------------|-----------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| First author, year | AMSTAR score | Intervention | Reported Outcome Domains |
| | | | <i>Summary of results</i> |
| Acar, 2012 | 0 | Video modeling, video self-modeling, video modeling combined with other practices | <p>SC: Yes RRB: No Additional Outcomes: Yes (self-care skills, daily life skills)</p> <p><i>Positive outcomes: social skills, play skills, language and communication skills, functional skills, self-care skills, daily life skills</i> <i>Negative outcomes: none</i> <i>Unclear outcomes: none</i> <i>Notes: Results suggest that video-modeling can be used to teach various behaviors and skills to individuals with autistic disorders and other developmental disabilities.</i></p> |
| Akulllian, 2009 | 1 | Video modeling, video self-modeling | <p>SC: Yes RRB: Yes Additional outcomes: Yes (functional skills)</p> <p><i>Positive outcomes: social communication, behavioral functioning, functional skills</i> <i>Negative outcomes: none</i> <i>Unclear outcomes: none</i> <i>Notes: Maintenance effects were moderate to high across outcome variables with the highest PND observed for functional skills, followed by behavioral functioning, and then SC. Generalization effects were low for SC and high for functional skills.</i></p> |
| Bellini, 2007 | 4 | Video modeling, video self-modeling | <p>SC: Yes RRB: No Additional outcomes: Yes (functional skills)</p> |

| | | | |
|----------------|---|--------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | | | <p><i>Positive outcomes: social communication, behavioral functioning, functional skills</i></p> <p><i>Negative outcomes: none</i></p> <p><i>Unclear outcomes: none</i></p> <p><i>Notes: Meta-analysis suggests that video modeling and video self-modeling are effective for a broad age range of children and adolescents and can be implemented in a variety of settings.</i></p> |
| Delano, 2007 | 2 | Video modeling | <p>SC: Yes</p> <p>RRB: Yes</p> <p>Additional outcomes: Yes (functional skills, problem behavior)</p> |
| | | | <p><i>Positive outcomes: social-communicative skills, functional skills, perspective-taking skills, problem behavior</i></p> <p><i>Negative outcomes:</i></p> <p><i>Unclear outcomes: social initiation, novel responses</i></p> <p><i>Notes: Positive gains for 50 of the 55 participants in one or more targeted skills. Video modeling may need to be combined with another intervention to produce positive results. Self-model procedures may be more effective than other as model procedures. Mixed results may be related to individual characteristics of participants.</i></p> |
| Kagohara, 2010 | 4 | Video-based instructions | <p>SC: Yes</p> <p>RRB: No</p> <p>Additional outcomes: yes (daily living skills, problem behaviors, academic skills)</p> |
| | | | <p><i>Positive outcomes: social communication, daily living skills, decrease problem behaviors</i></p> <p><i>Negative outcomes:</i></p> <p><i>Unclear outcomes: daytime urinary control, non-modeled play behavior</i></p> <p><i>Notes: Most studies reported positive results but many studies reported mixed outcomes. Some studies could not attribute improvements to video modeling alone and/or required modifications to produce positive results (e.g., addition of reinforcers, different model, further training). Interventions were effective for some, but not all participants.</i></p> |

| | | | |
|--------------------|---|---------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Mason, 2012 | 3 | Video modeling (other as model) | <p>SC: Yes RRB: No Additional outcomes: Yes (independent living)</p> <p><i>Positive outcomes: social-communicative, independent living, play</i> <i>Negative outcomes: none</i> <i>Unclear outcomes: none</i> <i>Notes: An overall IRD score of .83 was calculated for participants with ASD. Largest effects were noted in elementary aged children, on play outcomes, and when video modeling was used in combination with reinforcement.</i></p> |
| Mason, 2013 | 6 | Point-of-view video modeling | <p>SC: Yes RRB: No Additional outcomes: Yes</p> <p><i>Positive outcomes: social-communicative, independent living, play</i> <i>Negative outcomes:</i> <i>Unclear outcomes:</i> <i>Notes: An IRD score of .81 was calculated for participants with ASD. Preschool and elementary aged participants yielded moderate effect sizes (lower than secondary and post-secondary aged participants). Large effects for independent living skills, moderate effects for social-communicative skills.</i></p> |
| Shukla-Mehta, 2010 | 2 | Video instruction (video modeling, video self-modeling, point-of-view video modeling) | <p>SC: Yes RRB: Yes Additional outcomes: No</p> <p><i>Positive outcomes: SC responses (scripted verbal/motor responses, appropriate play, prosocial behavior, initiating, responding, etc.), decreases in problem/repetitive behavior</i> <i>Negative outcomes: none</i> <i>Unclear outcomes: no increases in unscripted responses or non-modeled motor behavior</i> <i>Notes: Most studies did not involve video modeling as an isolated intervention, (also included prompting, error correction, and reinforcement). Since there</i></p> |

| | | | |
|----------------|---|----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | | | <i>were only four studies in which researchers used video modeling alone, no conclusions can be made regarding its independent effectiveness.</i> |
| Thompson, 2014 | 8 | Video modeling | <p>SC: Yes RRB: Yes Additional outcomes: No</p> <p><i>Positive outcomes: social skills, communication skills, behavioral functioning</i> <i>Negative outcomes: none</i> <i>Unclear outcomes: none</i> Notes: <i>Meta-analysis results indicate that video modeling is an effective intervention strategy and meets criteria as an evidence-based practice (Horner et al., 2005) for addressing social and communication skills, as well as behavioral functioning in children and adolescents with ASD. Video modeling was found to be most beneficial for the nonverbal group of participants. Maintenance was observed.</i></p> |

| Augmentative and alternative communication (AAC) | | | |
|---------------------------------------------------------|---------------------|-------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| First author, year | AMSTAR score | Intervention | Reported Outcome Domains |
| | | | <i>Summary of results</i> |
| Chung, 2012 | 5 | AAC (communication book/board, electronic devices, | SC: Yes RRB: No Additional outcomes: Yes (inappropriate behavior) |
| | | | <i>Positive outcomes: peer interaction/engagement, initiation, reciprocity/turn taking, sharing behavior, decrease inappropriate behavior</i> <i>Negative outcomes: none</i> <i>Unclear outcomes: none</i> <i>Notes: Findings suggest that AAC interventions are promising for increasing peer interaction outcomes. Studies evaluated mostly low-tech AAC.</i> |
| Costantino, 2014 | 6 | AAC (PECS, sign, computer programs) | SC: Yes RRB: No Additional outcomes: No |
| | | | <i>Positive outcomes: vocabulary, turn taking, joint attention, requests</i> <i>Negative outcomes: none</i> <i>Unclear outcomes: none</i> <i>Notes: Conclusive evidence concerning the positive effects of AAC interventions for children with ASD still needs to be established. Conclusive efficacy of AAC interventions cannot be determined due to a lack of empirical evidence.</i> |
| Ganz, 2011 | 4 | AAC (PECS, SGD) | SC: Yes RRB: No Additional outcomes: Yes (aggression, challenging behavior, spelling) |
| | | | <i>Positive outcomes: social communication (picture requests/exchanges, vocalizations, SGD use)</i> <i>Negative outcomes: none</i> <i>Unclear outcomes: none</i> |

| | | | |
|----------------------|---|--------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | | | <i>Notes: Aided AAC had at least moderate effects on participants across all age ranges and diagnostic categories. Preschool aged participants had better outcomes than elementary or secondary aged participants.</i> |
| Ganz, 2012 (AAC1) | 5 | AAC (picture-based systems, PECS, SGDs) | SC: Yes RRB: No Additional outcomes: Yes (challenging/disruptive behavior, social skills) |
| | | | <i>Positive outcomes: communication skills (e.g., verbal utterances, requests, symbol comprehension), behavioral outcomes (decrease challenging/disruptive behavior) Negative outcomes: none Unclear outcomes: none Notes: This meta-analysis identified large effects for aided AAC on targeted behavioral outcomes in individuals with ASD (IRD = 0.99 for overall effects). Picture-based systems had smaller effects than other interventions.</i> |
| Ganz, 2014 | 4 | AAC (picture-based systems, PECS, SGDs) | SC: Yes RRB: Yes Additional outcomes: Yes (challenging/aggressive behavior, spelling) |
| | | | <i>Positive outcomes: communication (e.g., picture responses), social interactions, initiations, speech, decrease in challenging behavior, spelling Negative outcomes: none Unclear outcomes: Notes: Participants with ASD (and no additional comorbid disabilities) SGDs were significantly more effective than PECS. However, for participants with ASD and IDD, PECS is more effective than SGDs and other picture-based systems.</i> |
| Kent-Walsh, 2015 | 8 | AAC (partner instruction) | SC: Yes RRB: No Additional outcomes: No |

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|----------------|---|---------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | | | <p><i>Positive outcomes: communication (language, manding, verbal utterances, communicative turns, picture exchange)</i></p> <p><i>Negative outcomes: none</i></p> <p><i>Unclear outcomes: none</i></p> <p><i>Notes: The central finding of this review is that a body of evidence consistently indicates that communication partner instruction has positive effects on communication performance of individuals using AAC.</i></p> |
| Lorah, 2015 | 3 | Tablets/portable media (as SGDs) | <p>SC: Yes</p> <p>RRB: No</p> <p>Additional outcomes: Yes (aggression)</p> |
| | | | <p><i>Positive outcomes: communication (mands, question response)</i></p> <p><i>Negative outcomes: none</i></p> <p><i>Unclear outcomes: none</i></p> <p><i>Notes: 53 of the 57 total participants (93 %) acquired the ability to communicate using the iPod or iPad as a SGD, within the context of the study.</i></p> |
| Millar, 2006 | 5 | AAC (manual sign, non-electronic AAC) | <p>SC: Yes</p> <p>RRB: No</p> <p>Additional outcomes: No</p> |
| | | | <p><i>Positive outcomes: speech (expressive vocabulary, communicative functions; requests, comments)</i></p> <p><i>Negative outcomes: none</i></p> <p><i>Unclear outcomes: none</i></p> <p><i>Notes: Speech: 11% of participants showed no change, and 89% demonstrated gains in speech. No participants showed decreases in speech production. (These results include participants of all ages; not limited to children 0-12)</i></p> <p><i>Gains in speech were generally modest, but ceiling effects may have played a role.</i></p> |
| Raulston, 2013 | 4 | AAC, PECS, other | <p>SC: Yes</p> <p>RRB: No</p> <p>Additional outcomes: No</p> |

| | | | |
|--------------------------|---|----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | | | <p><i>Positive outcomes: question asking skills (mands for information)</i> <i>Negative outcomes: none</i> <i>Unclear outcomes: none</i> <i>Notes: The findings of this review suggest that systematic instructional procedures (e.g., prompting, and reinforcement) have been effective in teaching individuals with ASD to ask questions.</i></p> |
| Schlosser, 2008 (AAC) | 8 | AAC (manual sign, PECS, SGDs) | <p>SC: Yes RRB: No Additional outcomes: No</p> |
| | | | <p><i>Positive outcomes: speech (not impeded, modest gains)</i> <i>Negative outcomes: none</i> <i>Unclear outcomes: none</i> <i>Notes: Most studies reported modest increases in speech production for most participants (none reported a decline in speech).</i></p> |
| Van Der Meer, 2010 | 6 | SGDs | <p>SC: Yes RRB: Yes Additional outcomes: Yes (spelling, SGD behavior)</p> |
| | | | <p><i>Positive outcomes: communication behavior, requesting, commenting, answering questions, reducing preservative requesting/irrelevant speech,</i> <i>Negative outcomes: none</i> <i>Unclear outcomes: none</i> <i>Notes: Although further research is warranted, SGDs appear to be a viable communication options for children with autism. 87% of studies reported positive outcomes. 13% of studies reported mixed outcomes (not all participants showed positive effects). No studies reported negative effects.</i></p> |

| Picture exchange communication system (PECS) | | | |
|-----------------------------------------------------|---------------------|---------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| First author, year | AMSTAR score | Intervention | Reported Outcome Domains |
| | | | <i>Summary of results</i> |
| Flippin, 2010 | 5 | PECS | <p>SC: Yes RRB: No Additional outcomes: No</p> <p><i>Positive outcomes: communication (small to moderate effects; PECS exchanges, initiations, mands, requests, spontaneous language)</i> <i>Negative outcomes: none</i> <i>Unclear outcomes: speech (small to negative effects; utterances, word approximations, vocalizations)</i> <i>Notes: PECS is a promising intervention for promoting communication in children with ASD, but hasn't been established as an evidence-based practice. Concerns regarding maintenance and generalization were noted.</i></p> |
| Ganz, 2012 (PECS) | 3 | PECS | <p>SC: Yes RRB: No Additional outcomes: Yes (disruptive/challenging behavior)</p> <p><i>Positive outcomes: functional communication skills (e.g., interactions, initiations, requests), vocalizations, decreases in challenging behaviors</i> <i>Negative outcomes: none</i> <i>Unclear outcomes: non-functional language, non-target outcomes</i> <i>Notes: Mean IRD score was .56 with a range of .51 to .95. PECS has the potential to contribute to positive outcomes, but effects may be influenced by many factors. PECS users generally make the strongest gains on targeted outcomes related to functional communication skills. Effects reported for preschool children were greater than for elementary children.</i></p> |
| Hart, 2010 | 5 | PECS | <p>SC: Yes RRB: Yes Additional outcomes: No</p> |

| | | | |
|----------------------|---|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | | | <p><i>Positive outcomes: functional communication skills (e.g., mands), social behavior</i></p> <p><i>Negative outcomes: none</i></p> <p><i>Unclear outcomes: speech, non-verbal manding, decrease aggressive/problem behavior</i></p> <p><i>Notes: PECS was a highly effective intervention for 54% of participants, moderately effective for 29%, minimally effective for 17%, and showed no effect for 3%.</i></p> |
| Preston, 2009 | 5 | PECS | <p>SC: Yes</p> <p>RRB: Yes</p> <p>Additional outcomes: No</p> |
| | | | <p><i>Positive outcomes: social communication, decreases in challenging behavior</i></p> <p><i>Negative outcomes: none</i></p> <p><i>Unclear outcomes: speech development</i></p> <p><i>Notes: Preliminary evidence based on limited data suggests that PECS may be an effective intervention; it is able to be learned by most participants and provides a means of communication for individuals with little or no functional speech.</i></p> |
| Sulzer-Azaroff, 2009 | 3 | PECS | <p>SC: Yes</p> <p>RRB: No</p> <p>Additional outcomes: Yes (maladaptive behavior, aggression)</p> |
| | | | <p><i>Positive outcomes: functional communication (e.g., expression of wants, needs, observations)</i></p> <p><i>Negative outcomes: none</i></p> <p><i>Unclear outcomes: speech, social approach, decrease in maladaptive behavior and aggression</i></p> <p><i>Notes: Findings suggest that PECS is improving functional communication for those who have no or impaired speech. When compared to other communicative training methods, PECS outcomes were equal or better than the others.</i></p> |

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|---------------|---|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Tien, 2008 | 2 | PECS | <p>SC: Yes RRB: No Additional outcomes: Yes (problem behavior)</p> <hr/> <p><i>Positive outcomes: functional communication (e.g., mands, vocalization, imitation, initiation)</i> <i>Negative outcomes: none</i> <i>Unclear outcomes: reduction of problem behavior (reported only in some studies)</i> <i>Notes: Available research evidence suggests that PECS is an effective intervention for improving functional communication skills. Rates of acquisition for PECS were greater than for manual sign language.</i></p> |
| Tincani, 2011 | 4 | PECS | <p>SC: Yes RRB: No Additional outcomes: No</p> <hr/> <p><i>Positive outcomes: picture exchange, play, initiation</i> <i>Negative outcomes:</i> <i>Unclear outcomes: vocalization, speech</i> <i>Notes: Results suggest that PECS was moderately effective in establishing mands for participants diagnosed with autism or PDD-NOS (PND = 75.4).</i></p> |

| Activity Schedules | | | |
|---------------------------|---------------------|---------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| First author, year | AMSTAR score | Intervention | Reported Outcome Domains |
| | | | <i>Summary of results</i> |
| Banda, 2008 | 2 | Activity schedules | <p>SC: Yes RRB: No Additional outcomes: Yes (on-task/on-schedule behavior, transitions, independence, problem/tantrum behavior)</p> <p><i>Positive outcomes: social engagement/interaction, on-task/on-schedule behavior, transitions, independence, play behavior, decrease problem behavior, Negative outcomes: none Unclear outcomes: none Notes: Activity schedules had positive effects for all (31) participants.</i></p> |
| Knight, 2015 | 5 | Visual activity schedules | <p>SC: Yes RRB: No Additional outcomes: Yes (on-task/on-schedule behavior, transitions, independence, latency to task, task response/analysis)</p> <p><i>Positive outcomes: on-task/on-schedule behavior, transitions, independence, decrease level of prompts necessary for transitions, task response/analysis, decrease latency to task Negative outcomes: none Unclear outcomes: none Notes: Visual activity schedules qualify as an evidence-based practice for individuals with ASD, especially when used in combination with systematic instructional procedures.</i></p> |
| Lequia, 2012 | 3 | Activity schedules | <p>SC: Yes RRB: No Additional outcomes: Yes (routine completion time, on-task/on-schedule behavior, challenging behavior)</p> |

| | | | |
|--|--|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | | | <p><i>Positive outcomes: engagement, social initiation, routine completion time, decrease challenging/disruptive behavior</i></p> <p><i>Negative outcomes: none</i></p> <p><i>Unclear outcomes: none</i></p> <p><i>Notes: Degree of effectiveness varied across settings, severity of ASD diagnosis, and communication abilities.</i></p> |
|--|--|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

| Computer based interventions | | | |
|-------------------------------------|---------------------|------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| First author, year | AMSTAR score | Intervention | Reported Outcome Domains |
| | | | <i>Summary of results</i> |
| Ramdoss, 2011 | 5 | Computer-based interventions | SC: Yes RRB: Yes Additional outcomes: Yes (phonological awareness) |
| | | | <i>Positive outcomes: communication skills (vocabulary, imitation, expression, social greeting), phonological awareness, decreases in echolalia Negative outcomes: none Unclear outcomes: none Notes: Computer-based interventions produced mild effects. They should not yet be considered a researched-based approach to teaching communication skills to individuals with ASD. A limited literature base limits conclusions.</i> |
| Ramdoss, 2012 | 5 | Computer-based interventions | SC: Yes RRB: No Additional outcomes: Yes (social skills, emotional skills) |
| | | | <i>Positive outcomes: communication Negative outcomes: none Unclear outcomes: social skills, emotional skills (moderate effects) Notes: Computer based interventions are a promising practice and can be as effective as face-to-face instruction. Preferences and existing abilities of individuals with ASD should be considered, as should the software when choosing a computer program. In general, researcher-developed measures were associated with larger effects and standardized measures were associated with smaller effects.</i> |

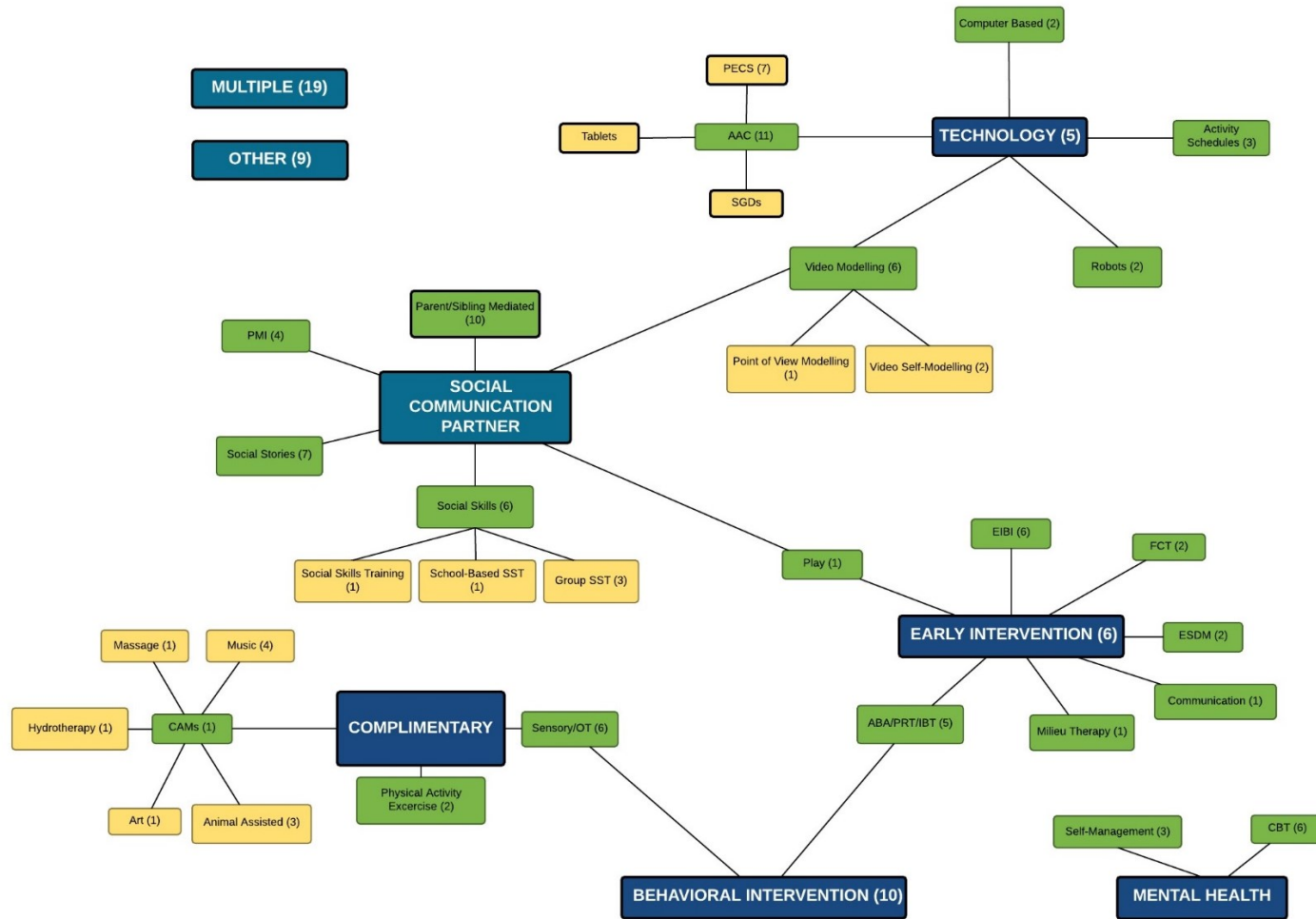
| Social robotics | | | |
|---------------------------|---------------------|---------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| First author, year | AMSTAR score | Intervention | Reported Outcome Domains |
| | | | <i>Summary of results</i> |
| Diehl, 2012 | 2 | Robots | SC: Yes RRB: No Additional outcomes: No |
| | | | <i>Positive outcomes: increased interaction (with robot) Negative outcomes: none Unclear outcomes: eliciting prosocial behavior (eye gaze, imitation of robot) Notes: Preliminary results indicate there is a possibility that participants with ASD prefer robot-like characteristics over non-robotic toys and humans and responded more quickly to robot-like cues. Robots are being used to elicit behavior, model and/or teach behavior, and to provide feedback. Peer-reviewed research on the topic is all preliminary or exploratory.</i> |
| Pennisi, 2016 | 3 | Social robotics | SC: Yes RRB: Yes Additional outcomes: No |
| | | | <i>Positive outcomes: social behavior, attention (to a robot), imitation, language, decreases in repetitive/stereotyped behavior Negative outcomes: none Unclear outcomes: joint attention Notes: Robotic therapy has brought positive results. Social robotics provides a means of connection. Most effective interactions take place in a clinical setting in free or semi-structured interactions.</i> |

| Other tech-mediated interventions | | | |
|------------------------------------------|---------------------|---------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| First author, year | AMSTAR score | Intervention | Reported Outcome Domains |
| | | | <i>Summary of results</i> |
| Aresti-Bartolome, 2014 | 1 | Various tech (virtual reality apps, telehealth, social robotics) | SC: Yes RRB: Yes Additional outcomes: No |
| | | | <i>Positive outcomes:</i> <i>Negative outcomes:</i> <i>Unclear outcomes:</i> <i>Notes: Technology serves as a key support instrument for people with ASD, their families or professionals treating them. Social learning and imitation skills, communication and interaction, telehealth for diagnosis/treatment. Lack of personalized tools. Communication, learning and social imitation, underlying conditions of ASD.</i> |
| Den Brok, 2015 | 2 | Self-controlled technology (e.g., videos on computers or handheld devices, virtual reality) | SC: Yes RRB: No Additional outcomes: Yes (daily living skills, cognitive concepts; time/emotion perception, imagination) |
| | | | <i>Positive outcomes: task performance, daily living skills, cognitive concepts, decrease in errors and need for prompts</i> <i>Negative outcomes: none</i> <i>Unclear outcomes: none</i> <i>Notes: Evidence suggests that technology supports learning of daily living skills and cognitive concepts in children with ASD. Task performance results can be maintained but might decline during the follow-up. More advanced technologies are suitable for learning new cognitive concepts.</i> |
| Grynszpan, 2014 | 4 | Various tech-based interventions | SC: Yes RRB: No Additional outcomes: Yes (social skills, object identification, reading, phonological awareness) |

| | | | |
|------------|---|--------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | | (virtual reality, computer programs) | <p><i>Positive outcomes: facial recognition, emotional recognition, vocabulary, reading, phonological awareness, object identification, social skills</i></p> <p><i>Negative outcomes: none</i></p> <p><i>Unclear outcomes: none</i></p> <p><i>Notes: Evidence supports tech-based interventions. When compared to a control group, test groups showed post-test differences. Meta-analysis of randomized controlled studies is in favor of tech-based interventions.</i></p> |
| Wass, 2014 | 2 | Cognitive training technologies | <p>SC: Yes</p> <p>RRB: No</p> <p>Additional outcomes: Yes (language/literacy, social skills)</p> <hr/> <p><i>Positive outcomes: social communication, joint attention, imitation, turn taking, theory of mind, social reasoning</i></p> <p><i>Negative outcomes: none</i></p> <p><i>Unclear outcomes: language/literacy</i></p> <p><i>Notes: Improvements fail to generalize to naturalistic environments.</i></p> |

*AAC, augmentative and alternative communication; PECS, picture exchange communication system; SGD, speech generating device; SC, social communication; RRB, restrictive or repetitive behavior; PND, percentage of non-overlapping data; IRD, improvement rate difference.

Figure 1: Web of Intervention



* Numbers in parentheses represent the number of SRs which were specifically identified with the corresponding intervention type.

** The upper right quadrant of Figure 1 represents SRs included in this umbrella review.

Figure 2: Flow diagram of study retrieval and selection process

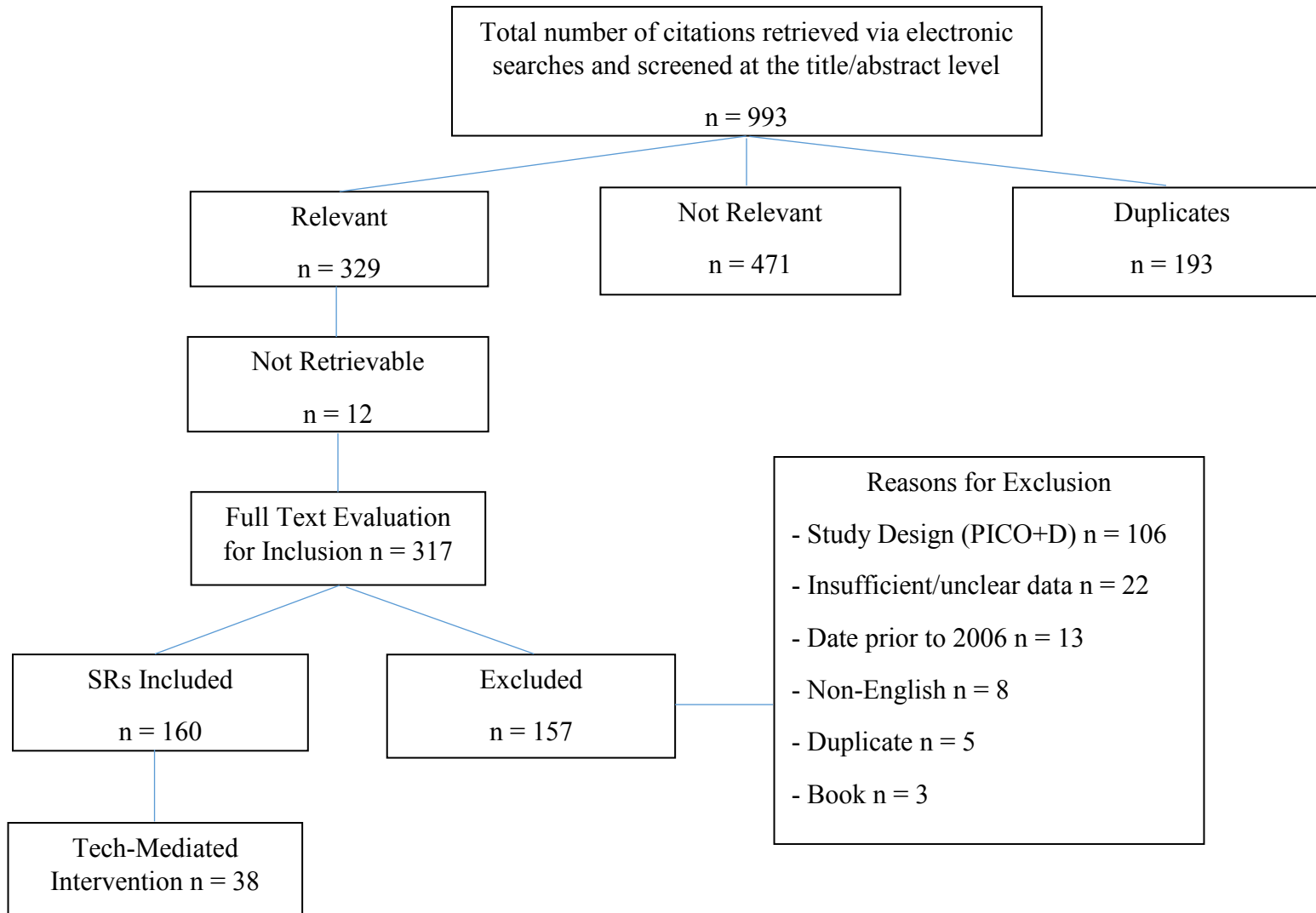
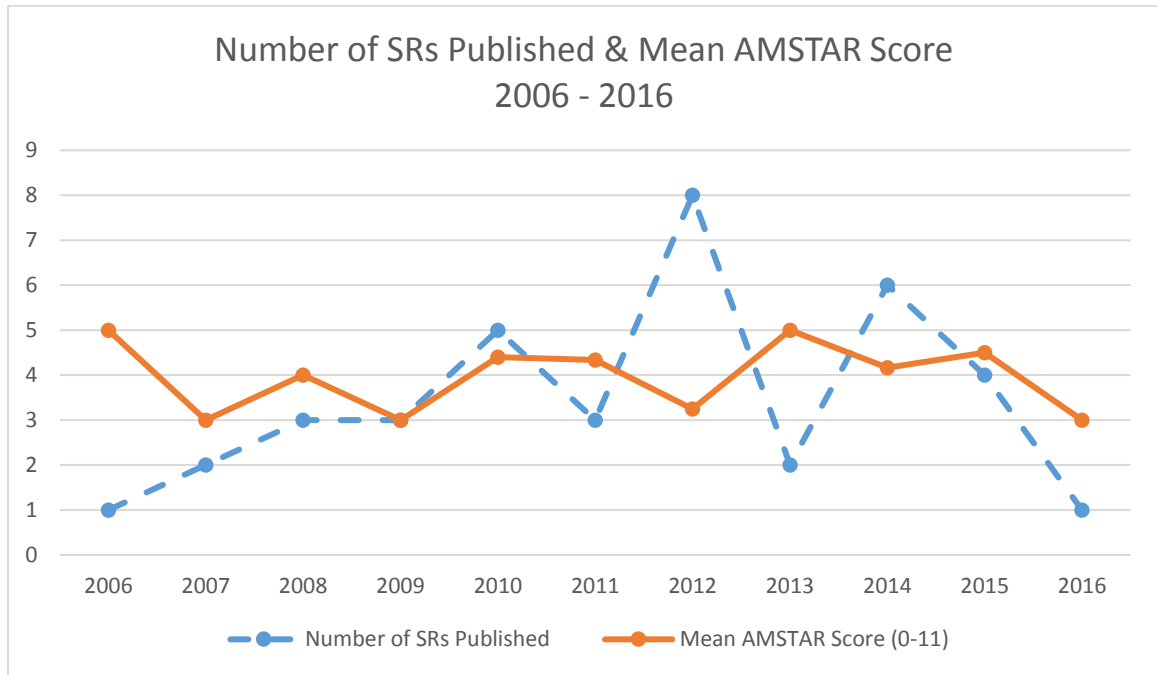


Figure 3: Tech-mediated ASD intervention reviews published annually and mean AMSTAR scores (n=38)



* Search was conducted in April 2016; number of studies published and mean AMSTAR score does not represent the entire 2016 year.

Figure 4: Total AMSTAR scores for systematic reviews of tech-mediated ASD interventions (n=38)

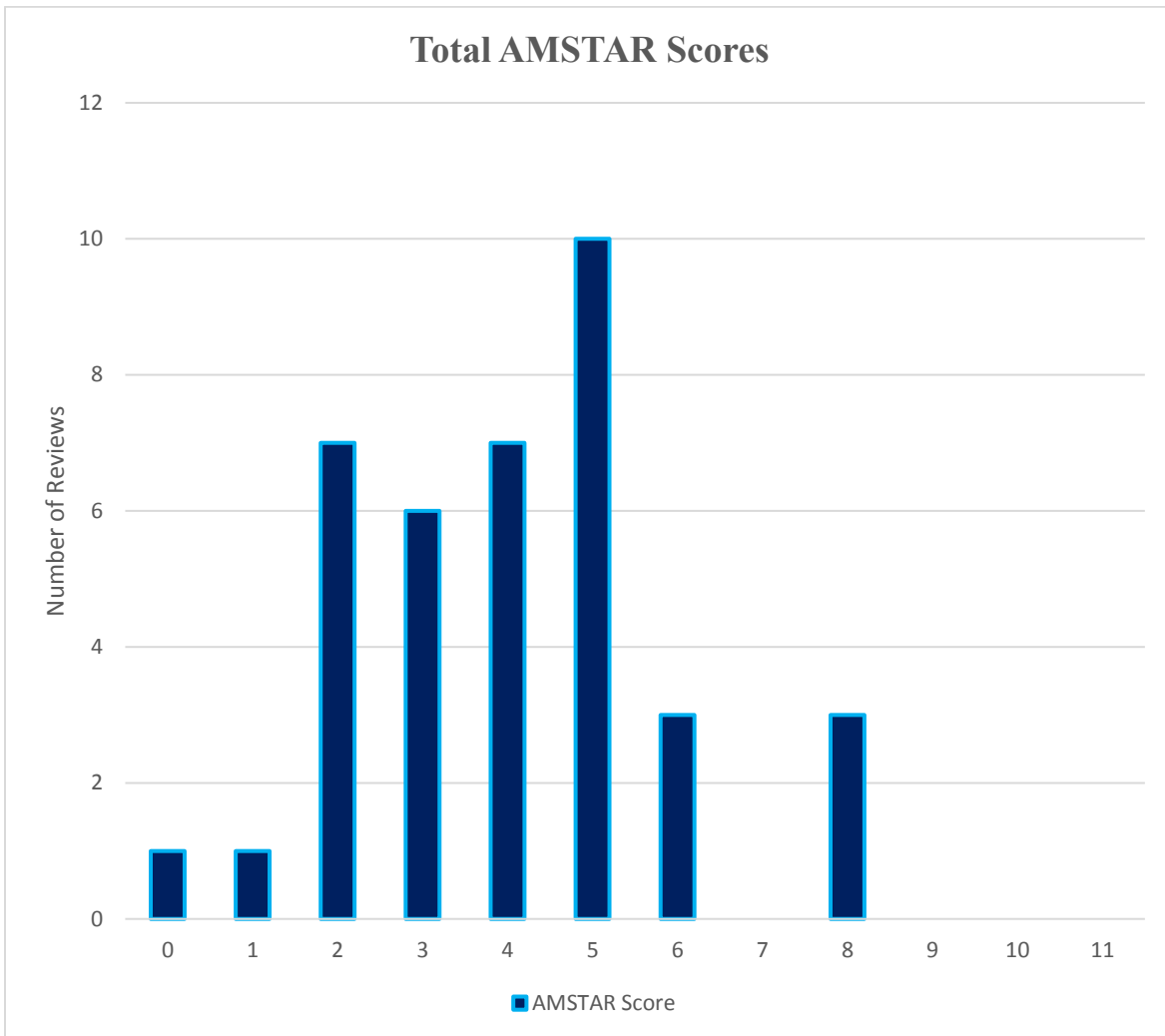


Figure 5: AMSTAR scores for each criteria

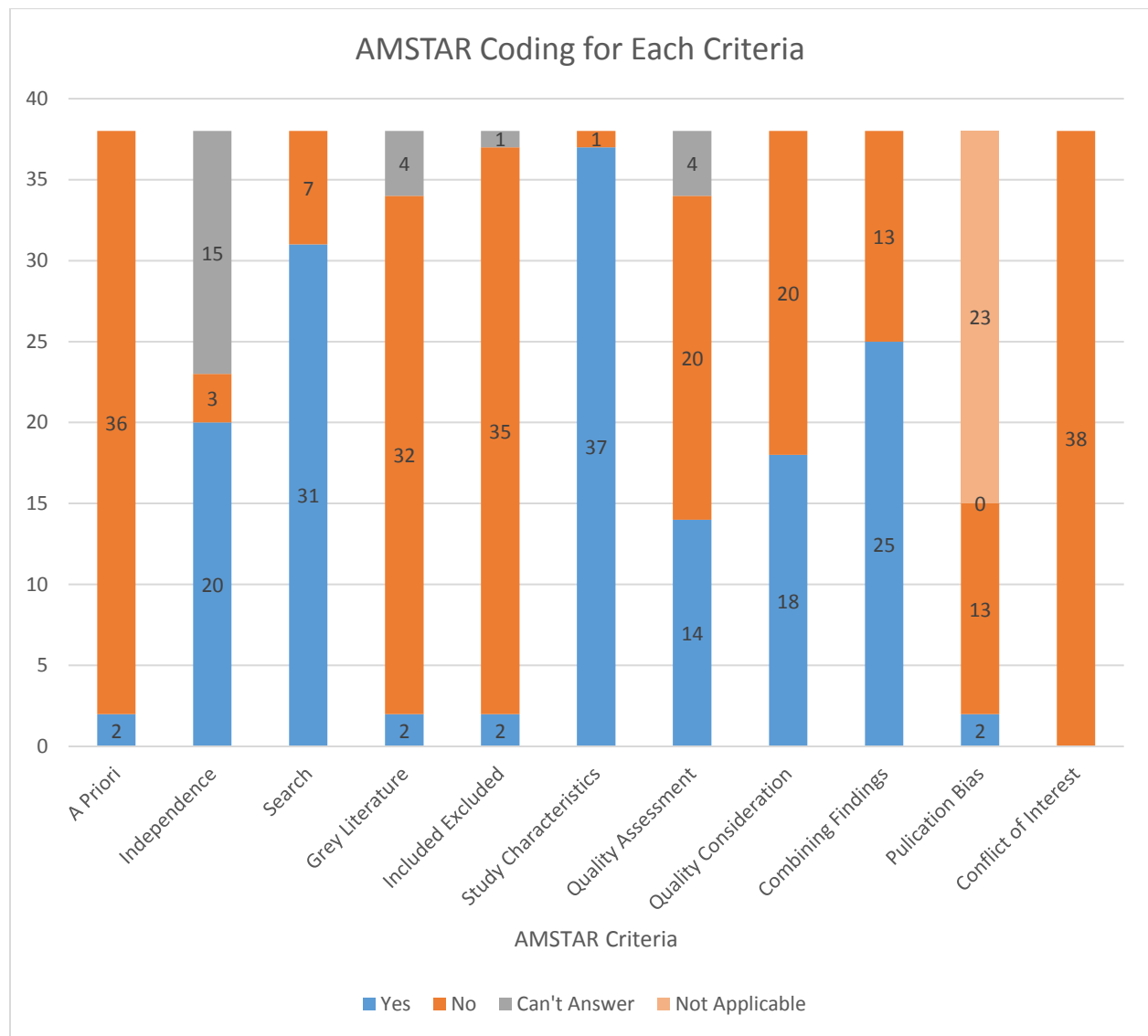
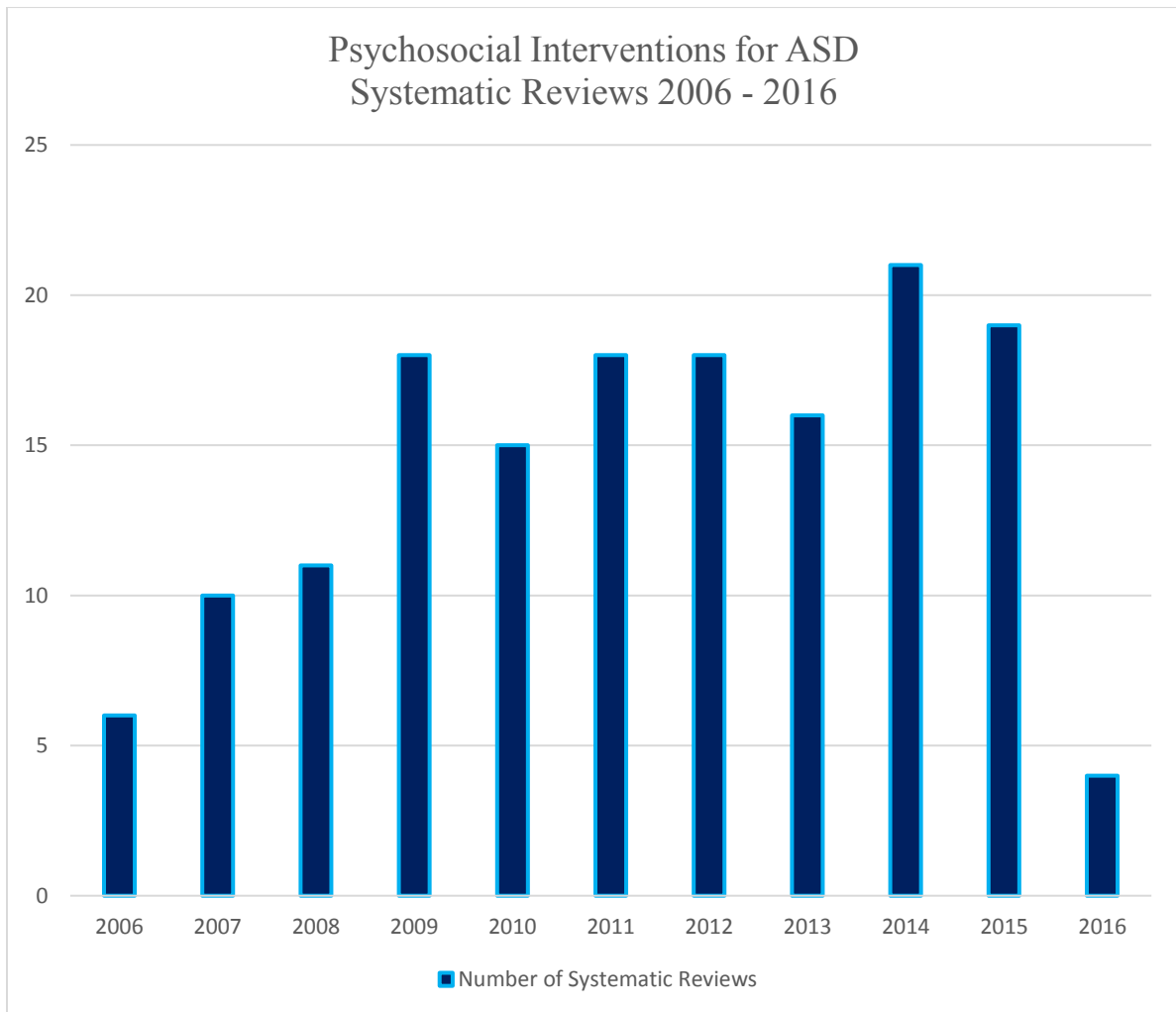
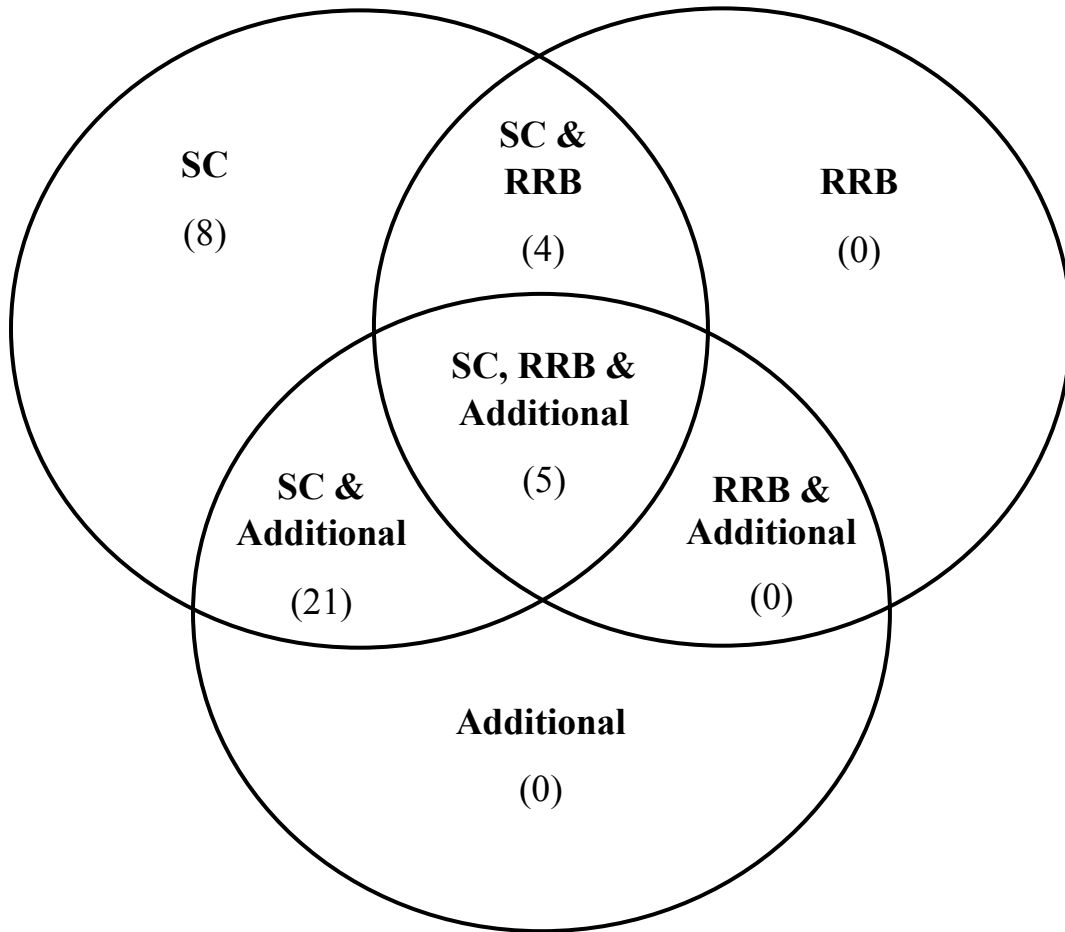


Figure 6: Psychosocial ASD intervention reviews published annually (n=160)



*Search was conducted in April 2016; number of studies published does not represent the entire 2016 year.

Figure 7: Outcome domains for systematic reviews of tech-mediated intervention (n=38)



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*Denotes SRs included in the present umbrella review

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Appendices

Appendix 1: Search strategy

A research librarian (Lisa Tjosvold) conducted a comprehensive literature search for publications published between January 2006 and April 2016 in the following electronic databases: Medline, ERIC, PsychINFO, Cochrane Database of Systematic Reviews, DARE and the HTA Database. The searches were restricted to systematic reviews. The search was developed a priori and carried out prior to the study selection process.

| Database | Edition or date searched | Search Terms ^{††} |
|---------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations, Ovid MEDLINE(R) Daily and Ovid MEDLINE(R) 1946 to Present</p> | <p>Searched: April 13, 2016 Results: 368 (English) 22(Non English)</p> | <ol style="list-style-type: none"> 1. exp Child Development Disorders, Pervasive/ 2. exp Autistic Disorder/ 3. autis\$.ti,hw,kw. 4. autis*.ab. /freq=2 5. asd.ti,ab. 6. kanner\$.ti,ab. 7. asperger\$.ti,ab. 8. (pervasive and development and disorder).ti,ab. 9. PDD.ti,ab. 10. pdd-nos.ti,ab. 11. childhood disintegrative disorder.ti,ab. 12. ((speech or communicat\$) adj3 disorder\$.ti,ab. 13. (child\$ adj3 schizopren\$).ti,ab,sh. 14. (language adj3 delay\$).ti,ab. 15. or/1-14 16. exp Behavior Therapy/ 17. exp Imitative Behavior/ 18. ((behavio\$ or social) adj5 (therap\$ or interven\$ or analy*)).ti,ab,jn. 19. ABA.ti,ab. 20. (IBI or IBT).ti,ab. 21. verbal behavio\$.ti,ab. 22. (verbal adj5 (therap\$ or communicat\$)).ti,ab. 23. lovaas.ti,ab. 24. linwood.ti,ab. 25. Douglass.ti,ab. 26. CABAS.ti,ab. 27. DTT.ti,ab. 28. (Treatment adj2 Education adj2 Autistic adj communication adj Handicapped adj children).ti,ab. 29. teacch.ti,ab. 30. floor time.ti,ab. 31. (Social adj Communication adj Emotional adj Regulation adj Transactional adj Support).ti,ab. 32. scerts.ti,ab. 33. (pivotal adj3 response).ti,ab. 34. discrete trial\$.ti,ab. 35. (((sensory or auditory) adj integration) and (treat\$ or therap\$)).mp. 36. facilitated communication.ti,ab. 37. ((parent or parents or caregiver\$ or care-giver\$ or family or families or mother\$ or father\$ or maternal\$ or paternal\$) adj2 (treat\$ or therap\$ or interven\$ or direct\$ or program\$ or train\$ or mediat\$ or rehabilit\$)).mp. 38. Picture Exchange.ti,ab. |

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| | | <p>39. photic stimulation/ and (treat\$ or therap\$ or interven\$ or direct\$ or program\$ or train\$ or mediat\$ or rehabilit\$).mp. 40. exp Language Therapy/ or exp Speech Therapy/ 41. occupational therapy/ 42. exp Computer-Assisted Instruction/ 43. (assist\$ adj3 tech\$).ti,ab. 44. (computer adj3 (teach\$ or instruct\$)).ti,ab. 45. (ipad or podd or tablet or chromebook).ti,ab. 46. exp Sensory Art Therapies/ or Play Therapy/ 47. exp Animal Assisted Therapy/ 48. ((music or art or dance or play or animal or animals or dog or cat or pet) adj2 therap*).ti,ab. 49. Early Intervention/ 50. (computer adj3 (teach\$ or instruct\$)).ti,ab. 51. (social adj (stories or narrative*)).ti,ab. 52. prompt\$.mp. 53. ((augment\$ or social) adj3 communicat\$).ti,ab. 54. (relationship adj develop\$).ti,ab. 55. (cognitive and (treat\$ or therap\$ or psychotherap\$)).mp. 56. cbt.ti,ab. 57. (sound adj3 (treat\$ or therap\$)).ti,ab. 58. (natural adj environment).ti,ab. 59. (activity adj schedule\$).ti,ab. 60. (direct adj instruct\$).ti,ab. 61. (giant adj step\$).ti,ab. 62. developmental individual difference.ti,ab. 63. option.ti,ab. 64. (sonrise or kaufman).ti,ab. 65. precision.ti,ab. 66. (social adj (skill* or pragmatic)).ti,ab. 67. hanen.ti,ab. 68. miller.ti,ab. 69. patterning\$.ti,ab. 70. philadelphia.ti,ab. 71. (dolman or delaccato).ti,ab. 72. (echange adj3 developpement).ti,ab. 73. bartelemy.ti,ab. 74. (gentle adj teach\$).ti,ab. 75. denver.ti,ab. 76. leap.ti,ab. 77. (learning experiences adj alternative program).ti,ab. 78. pcdi.ti,ab. 79. princeton child development institute.ti,ab,af. 80. rutgers.ti,ab. 81. (natural adj teach\$).ti,ab. 82. milieu.ti,ab. 83. (neurodevelop\$ adj treat\$).ti,ab. 84. ndt.ti,ab. 85. walden.ti,ab. 86. adlerian.ti,ab. 87. theraplay.ti,ab. 88. Eden.ti,ab. 89. "early bird".ti,ab. 90. (video adj3 model\$).ti,ab. 91. (self adj3 (manage\$ or monitor\$)).ti,ab. 92. yale.ti,ab. 93. bancroft.ti,ab. 94. horizon.ti,ab. 95. (may adj institute).ti,ab. 96. task analysis.mp. 97. chaining.mp. 98. (restrict* adj2 repetitive pattern*).mp. 99. "symbol use".mp. 100. attention/ or joint attention.ti,ab. 101. exp "Reinforcement (Psychology)"/ 102. Conditioning, Operant/ 103. (differential adj2 reinforce*).ti,ab. 104. time delay.ti,ab. 105. exp peer group/ and exp teaching/ 106. (peer adj2 (mediat* or instruct* or teach* or learn* or tutor*)).ti,ab. 107. (function* adj2 behavio?r* adj assess*).ti,ab.</p> |
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| | | <p>108. fba.ti.ab. 109. (stimulus adj3 (control or modif*)).ti.ab. 110. extinction.ti.ab. 111. (response interrupt* adj2 redirect*).mp. 112. RIRD.ti.ab. 113. exp Social Skills/ and group*.ti.ab. 114. (visual adj2 (script* or support* or aids or aid)).mp. 115. voca.ti.ab. 116. "Augmentative and alternative communication".kw. 117. "communication intervention".kw. 118. ((speech or communicat*) adj3 device*).ti.ab. 119. or/16-118 120. 15 and 119 121. meta-analysis.pt. 122. (meta-anal\$ or metaanal\$).mp. 123. ((quantitativ\$ adj3 review\$1) or (quantitativ\$ adj3 overview\$)).mp. 124. ((systematic\$ adj3 review\$) or (systematic adj3 overview\$)).mp. 125. ((methodologic adj3 review\$1) or (methodologic adj3 overview\$)).mp. 126. (integrat\$ adj5 research).mp. 127. (quantitativ\$ adj3 synthes\$).mp. 128. or/121-127 129. review.pt. or (review\$ or overview\$).mp. 130. (medline or medlars or pubmed or index medicus or embase or cochrane).mp. 131. (scisearch or web of science or psycinfo or psychinfo or cinahl or cinhal).mp. 132. (excerpta medica or psychlit or psyclit or current contents or science citation index or sciences citation index or scopus).mp. 133. (hand search\$ or manual search\$).mp. 134. ((electronic adj3 database\$) or (bibliographic adj3 database\$) or periodical index\$).mp. 135. (pooling or pooled or mantel haenszel).mp. 136. (peto or der simonian or dersimonian or fixed effect\$).mp. 137. ((combine\$ or combining) adj5 (data or trial or trials or studies or study or result or results)).mp. 138. or/130-137 139. 129 and 138 140. (hta\$ or health technology assessment\$ or biomedical technology assessment\$).mp. 141. technology assessment, biomedical/ or biomedical technology assessment/ 142. 128 or 139 or 140 or 141 143. limit 120 to "systematic reviews" 144. 120 and 142 145. 143 or 144 146. limit 145 to yr="2006 -Current" 147. remove duplicates from 146 148. limit 147 to english language</p> |
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| <p>ERIC 1965 to February 2016</p> | <p>Searched: April 13, 2016 Results: 244</p> | <ol style="list-style-type: none"> 1. exp Pervasive Developmental Disorders/ 2. exp Autism/ 3. exp Asperger Syndrome/ 4. autis\$.mp. 5. kanner\$.ti,ab. 6. asperger\$.ti,ab. 7. (pervasive and development and disorder).ti,ab. 8. PDD.ti,ab. 9. pdd-nos.ti,ab. 10. childhood disintegrative disorder.ti,ab. 11. ((speech or communicat\$) adj3 disorder\$).ti,ab,sh. 12. (child\$ adj3 schizophren\$).ti,ab,sh. 13. (language adj3 delay\$).ti,ab. 14. Delayed Speech/ 15. or/1-14 16. exp Behavior Modification/ 17. exp Behavior Change/ 18. exp IMITATION/ 19. exp Special Education/ 20. exp Classroom Techniques/ 21. Cognitive Restructuring/ 22. ((behavio\$ or social) adj5 (therap\$ or interven\$ or analy*)).ti,ab,jn. 23. ABA.ti,ab. 24. (IBI or IBT).ti,ab. 25. exp Verbal Communication/ 26. verbal behavio\$.ti,ab. 27. (verbal adj5 (therap\$ or communicat\$)).ti,ab. 28. exp Speech Therapy/ 29. occupational therapy/ 30. Music Therapy/ or Art Therapy/ or Dance Therapy/ or Play Therapy/ 31. ((music or art or dance or play or animal or animals or dog or cat or pet) adj2 therap*).ti,ab. 32. lovaas.ti,ab. 33. linwood.ti,ab. 34. Douglass.ti,ab. 35. CABAS.ti,ab. 36. DTT.ti,ab. 37. (Treatment adj2 Education adj2 Autistic adj communication adj Handicapped adj children).ti,ab. 38. teacch.ti,ab. 39. floor time.ti,ab. 40. (Social adj Communication adj Emotional adj Regulation adj Transactional adj Support).ti,ab. 41. scerts.ti,ab. 42. (pivotal adj 3 response).ti,ab. 43. discrete trial\$.ti,ab. 44. exp Sensory Integration/ 45. (((sensory or auditory) adj integration) and (treat\$ or therap\$)).mp. 46. facilitated communication.ti,ab. 47. ((parent or parents or caregiver\$ or care-giver\$ or family or families or mother\$ or father\$ or maternal\$ or paternal\$) adj2 (treat\$ or therap\$ or interven\$ or direct\$ or program\$ or train\$ or mediat\$ or rehabilitat\$)).mp. 48. Picture Exchange.ti,ab. 49. exp Computer-Assisted Instruction/ 50. exp Assistive Technology/ 51. (assist\$ adj3 tech\$).ti,ab. 52. (computer adj3 (teach\$ or instruct\$)).ti,ab. 53. (ipad or podd or tablet or chromebook).ti,ab. 54. exp Early Intervention/ 55. (social adj (stories or narrative*)).ti,ab. 56. exp Prompting/ 57. prompt\$.mp. 58. exp "augmentative and alternative communication"/ 59. ((augment\$ or social) adj3 communicat\$).ti,ab. 60. (relationship adj develop\$).ti,ab. 61. (cognitive and (treat\$ or therap\$ or psychotherap\$)).mp. 62. cbt.ti,ab. 63. (natural adj environment).ti,ab. 64. (activity adj schedule\$).ti,ab. 65. (direct adj instruct\$).ti,ab. 66. (giant adj step\$).ti,ab. |
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| | | <p>67. developmental individual difference.ti,ab. 68. option.ti,ab. 69. (sonrise or kaufman).ti,ab. 70. precision.ti,ab. 71. exp Interpersonal Competence/ and exp Skill Development/ 72. (social adj (pragmatic or skill*)).ti,ab. 73. hanen.ti,ab. 74. miller.ti,ab. 75. patterning\$.ti,ab. 76. philadelphia.ti,ab. 77. (dolman or delacatto).ti,ab. 78. (echange adj 3 developpement).ti,ab. 79. bartelemy.ti,ab. 80. (gentle adj teach\$.ti,ab. 81. denver.ti,ab. 82. leap.ti,ab. 83. (learning experiences adj alternative program).ti,ab. 84. pcdi.ti,ab. 85. princeton child development institute.ti,ab,af. 86. rutgers.ti,ab. 87. (natural adj teach\$.ti,ab. 88. milieu.ti,ab. 89. (neurodevelop\$ adj treat\$.ti,ab. 90. ndt.ti,ab. 91. walden.ti,ab. 92. adlerian.ti,ab. 93. theraplay.ti,ab. 94. Eden.ti,ab. 95. (early adj bird).ti,ab. 96. (video adj3 model\$.ti,ab. 97. (self adj3 (manage\$ or monitor\$)).ti,ab. 98. (yale or bancroft or horizon).ti,ab. 99. (may adj institute).ti,ab. 100. task analysis.mp. 101. exp task analysis/ 102. (restrict* adj2 repetitive pattern*).mp. 103. "symbol use".mp. 104. attention/ 105. joint attention.ti,ab. 106. exp reinforcement/ 107. chaining.mp. 108. time delay.mp. 109. exp Peer Teaching/ or peer-mediated.mp. 110. exp functional behavioral assessment/ 111. fba.mp. 112. (function* adj2 behavio?r* adj assess*).ti,ab. 113. (stimulus adj3 (control or modif*)).ti,ab. 114. extinction.mp. 115. (response interrupt* adj2 redirect*).mp. 116. RIRD.ti,ab. 117. differential reinforc*.mp. 118. (visual adj2 (script* or support* or aids or aid)).mp. 119. voca.ti,ab. 120. ((speech or communicat*) adj3 device*).ti,ab. 121. or/16-120 122. 15 and 121 123. meta analysis/ 124. exp Literature Reviews/ 125. ((systematic* adj3 (review* or overview*)) or (methodologic* adj3 (review* or overview*))).ti,ab. 126. ((quantitative adj3 (review* or overview* or synthes*)) or (research adj3 (integrati* or overview*))).ti,ab. 127. ((integrative adj3 (review* or overview*)) or (collaborative adj3 (review* or overview*)) or (pool* adj3 analy*).ti,ab. 128. (data synthes* or data extraction* or data abstraction*).ti,ab. 129. (handsearch* or hand search*).ti,ab. 130. (mantel haenszel or peto or der simonian or dersimonian or fixed effect* or latin square*).ti,ab. 131. (met analy* or metanaly* or technology assessment* or HTA or HTAs or technology overview* or technology appraisal*).ti,ab.</p> |
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| | | <p>132. (meta regression* or metaregression*).ti,ab. 133. (meta-analy* or metaanaly* or systematic review* or biomedical technology assessment* or bio-medical technology assessment*).mp,hw. 134. (medline or cochrane or pubmed or medlars or embase or cinahl).ti,ab,hw. 135. (comparative adj3 (efficacy or effectiveness)).ti,ab. 136. (outcomes research or relative effectiveness).ti,ab. 137. ((indirect or indirect treatment or mixed-treatment) adj comparison*).ti,ab. 138. or/123-137 139. 122 and 138 140. limit 139 to yr="2006 -Current"</p> |
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| <p>PsycINFO 2002 to April Week 1 2016</p> | <p>Searched: April 13, 2016</p> <p>Results: 337</p> | <ol style="list-style-type: none"> 1. autism spectrum disorders/ 2. autis\$.mp. 3. kanner\$.ti,ab. 4. asperger\$.ti,ab. 5. (pervasive and development and disorder).ti,ab. 6. PDD.ti,ab. 7. pdd-nos.ti,ab. 8. childhood disintegrative disorder.ti,ab. 9. ((speech or communicat\$) adj3 disorder\$.ti,ab,sh. 10. (child\$ adj3 schizophren\$.ti,ab,sh. 11. (language adj3 delay\$.ti,ab. 12. Delayed Speech/ 13. or/1-12 14. exp communication skills training/ or exp social skills training/ 15. exp Behavior Modification/ 16. exp Behavior Change/ 17. exp social Learning/ 18. exp Special Education/ 19. ((behavio\$ or social) adj5 (therap\$ or interven\$ or analy*\$)).ti,ab,jn. 20. ABA.ti,ab. 21. (IBI or IBT).ti,ab. 22. exp Verbal Communication/ 23. verbal behavio\$.ti,ab. 24. (verbal adj5 (therap\$ or communicat\$)).ti,ab. 25. exp Speech Therapy/ 26. occupational therapy/ 27. exp Movement Therapy/ or Play Therapy/ 28. Animal Assisted Therapy/ 29. exp Creative Arts Therapy/ 30. ((music or art or dance or play or animal or animals or dog or cat or pet) adj2 therap*).ti,ab. 31. lovaas.ti,ab. 32. linwood.ti,ab. 33. Douglass.ti,ab. 34. CABAS.ti,ab. 35. DTT.ti,ab. 36. (Treatment adj2 Education adj2 Autistic adj communication adj Handicapped adj children).ti,ab. 37. teacch.ti,ab. 38. floor time.ti,ab. 39. (Social adj Communication adj Emotional adj Regulation adj Transactional adj Support).ti,ab. 40. scerts.ti,ab. 41. (pivotal adj 3 response).ti,ab. 42. discrete trial\$.ti,ab. 43. exp Sensory Integration/ 44. (((sensory or auditory) adj integration) and (treat\$ or therap\$)).mp. 45. facilitated communication.ti,ab. 46. ((parent or parents or caregiver\$ or care-giver\$ or family or families or mother\$ or father\$ or maternal\$ or paternal\$) adj2 (treat\$ or therap\$ or interven\$ or direct\$ or program\$ or train\$ or mediat\$ or rehabilit\$)).mp. 47. Picture Exchange.ti,ab. 48. exp Computer-Assisted Instruction/ 49. exp Assistive Technology/ 50. (assist\$ adj3 tech\$.ti,ab. 51. (computer adj3 (teach\$ or instruct\$)).ti,ab. 52. (ipad or podd or tablet or chromebook).ti,ab. 53. exp Early Intervention/ 54. (social adj (stories or narrative*\$)).ti,ab. 55. exp Prompting/ 56. prompt\$.mp. 57. exp augmentative communication/ 58. ((augment\$ or social) adj3 communicat\$).ti,ab. 59. (relationship adj develop\$.ti,ab. 60. (cognitive and (treat\$ or therap\$ or psychotherap\$)).mp. 61. cbt.ti,ab. 62. (natural adj environment).ti,ab. 63. (activity adj schedule\$.ti,ab. 64. (direct adj instruct\$.ti,ab. 65. (giant adj step\$.ti,ab. 66. developmental individual difference.ti,ab. |
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| | | <p>67. option.ti,ab. 68. (sonrise or kaufman).ti,ab. 69. precision.ti,ab. 70. (exp Communication Skills/ or exp Interpersonal Interaction/) and exp Skill Learning/ 71. (social adj (pragmatic or skill*)).ti,ab. 72. hanen.ti,ab. 73. miller.ti,ab. 74. patterning\$.ti,ab. 75. philadelphia.ti,ab. 76. (dolman or delaccato).ti,ab. 77. (echange adj 3 developpement).ti,ab. 78. bartelemy.ti,ab. 79. (gentle adj teach\$).ti,ab. 80. denver.ti,ab. 81. leap.ti,ab. 82. (learning experiences adj alternative program).ti,ab. 83. pcdi.ti,ab. 84. princeton child development institute.ti,ab,af. 85. rutgers.ti,ab. 86. (natural adj teach\$).ti,ab. 87. milieu.ti,ab. 88. (neurodevelop\$ adj treat\$).ti,ab. 89. ndt.ti,ab. 90. walden.ti,ab. 91. adlerian.ti,ab. 92. theraplay.ti,ab. 93. Eden.ti,ab. 94. (early adj bird).ti,ab. 95. (video adj3 model\$).ti,ab. 96. (self adj3 (manage\$ or monitor\$)).ti,ab. 97. (yale or bancroft or horizon).ti,ab. 98. (may adj institute).ti,ab. 99. task analysis.mp. 100. exp task analysis/ 101. (restrict* adj2 repetitive pattern*).mp. 102. "symbol use".mp. 103. attention/ 104. joint attention.ti,ab. 105. exp reinforcement/ 106. chaining.mp. 107. time delay.mp. 108. exp Peer Tutoring/ or peer-mediated.mp. 109. exp Behavioral Assessment/ and exp Functional Analysis/ 110. fba.mp. 111. (function* adj2 behavio?r* adj assess*).ti,ab. 112. (stimulus adj3 (control or modif*)).ti,ab. 113. "Extinction (Learning)"/ 114. extinction.mp. 115. (response interrupt* adj2 redirect*).mp. 116. RIRD.ti,ab. 117. differential reinforc*.mp. 118. (visual adj2 (script* or support* or aids or aid)).mp. 119. voca.ti,ab. 120. ((speech or communicat*) adj3 device*).ti,ab. 121. or/14-120 122. 13 and 121 123. meta analysis/ 124. ((systematic* adj3 (review* or overview*)) or (methodologic* adj3 (review* or overview*))).ti,ab. 125. ((quantitative adj3 (review* or overview* or synthes*)) or (research adj3 (integrati* or overview*))).ti,ab. 126. ((integrative adj3 (review* or overview*)) or (collaborative adj3 (review* or overview*)) or (pool* adj3 analy*).ti,ab. 127. (data synthes* or data extraction* or data abstraction*).ti,ab. 128. (handsearch* or hand search*).ti,ab. 129. (mantel haenszel or peto or der simonian or dersimonian or fixed effect* or latin square*).ti,ab. 130. (met analy* or metanaly* or technology assessment* or HTA or HTAs or technology overview* or technology appraisal*).ti,ab. 131. (meta regression* or metaregression*).ti,ab.</p> |
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| | | <p>132. (meta-analy* or metaanaly* or systematic review* or biomedical technology assessment* or bio-medical technology assessment*).ti,ab,hw. 133. (medline or cochrane or pubmed or medlars or embase or cinahl).ti,ab,hw. 134. (comparative adj3 (efficacy or effectiveness)).ti,ab. 135. (outcomes research or relative effectiveness).ti,ab. 136. ((indirect or indirect treatment or mixed-treatment) adj comparison*).ti,ab. 137. or/123-136 138. 122 and 137 139. limit 122 to "0830systematic review" 140. 138 or 139 141. limit 140 to yr="2006 -Current" 142. limit 141 to (abstract collection or bibliography or "column/opinion" or "comment/reply" or editorial or encyclopedia entry or "erratum/correction" or letter or obituary or poetry or publication information or reprint or review-book or review-media or review-software & other) 143. 141 not 142 144. limit 143 to ("0110 peer-reviewed journal" or "0280 edited book" or "0400 dissertation abstract")</p> |
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| <p>EBM Reviews – Cochrane Database of Systematic Reviews 2005 to April 07, 2016</p> <p>EBM Reviews – Database of Abstracts of Reviews of Effects 1st Quarter 2016</p> <p>EBM Reviews – Health Technology Assessment 1st Quarter 2016</p> | <p>Searched: April 13, 2016</p> <p>CDSR: 44</p> <p>DARE: 59</p> <p>HTA: 29</p> | <ol style="list-style-type: none"> 1. exp Child Development Disorders, Pervasive/ 2. exp Autistic Disorder/ 3. autis\$.ti,hw,kw. 4. autis*.ab. /freq=2 5. asd.ti,ab. 6. kanner\$.ti,ab. 7. asperger\$.ti,ab. 8. (pervasive and development and disorder).ti,ab. 9. PDD.ti,ab. 10. pdd-nos.ti,ab. 11. childhood disintegrative disorder.ti,ab. 12. ((speech or communicat\$) adj3 disorder\$).ti,ab. 13. (child\$ adj3 schizophren\$).ti,ab,sh. 14. (language adj3 delay\$).ti,ab. 15. or/1-14 16. exp Behavior Therapy/ 17. exp Imitative Behavior/ 18. ((behavio\$ or social) adj5 (therap\$ or interven\$ or analy*\$)).ti,ab,jn. 19. ABA.ti,ab. 20. (IBI or IBT).ti,ab. 21. verbal behavio\$.ti,ab. 22. (verbal adj5 (therap\$ or communicat\$)).ti,ab. 23. lovaas.ti,ab. 24. linwood.ti,ab. 25. Douglass.ti,ab. 26. CABAS.ti,ab. 27. DTT.ti,ab. 28. (Treatment adj2 Education adj2 Autistic adj communication adj Handicapped adj children).ti,ab. 29. teacch.ti,ab. 30. floor time.ti,ab. 31. (Social adj Communication adj Emotional adj Regulation adj Transactional adj Support).ti,ab. 32. scerts.ti,ab. 33. (pivotal adj3 response).ti,ab. 34. discrete trial\$.ti,ab. 35. (((sensory or auditory) adj integration) and (treat\$ or therap\$)).mp. 36. facilitated communication.ti,ab. 37. ((parent or parents or caregiver\$ or care-giver\$ or family or families or mother\$ or father\$ or maternal\$ or paternal\$) adj2 (treat\$ or therap\$ or interven\$ or direct\$ or program\$ or train\$ or mediat\$ or rehabilit\$)).mp. 38. Picture Exchange.ti,ab. 39. photic stimulation/ and (treat\$ or therap\$ or interven\$ or direct\$ or program\$ or train\$ or mediat\$ or rehabilit\$).mp. 40. exp Language Therapy/ or exp Speech Therapy/ 41. occupational therapy/ 42. exp Computer-Assisted Instruction/ 43. (assist\$ adj3 tech\$).ti,ab. 44. (computer adj3 (teach\$ or instruct\$)).ti,ab. 45. (ipad or podd or tablet or chromebook).ti,ab. 46. exp Sensory Art Therapies/ or Play Therapy/ 47. exp Animal Assisted Therapy/ 48. ((music or art or dance or play or animal or animals or dog or cat or pet) adj2 therap*).ti,ab. 49. Early Intervention/ 50. (computer adj3 (teach\$ or instruct\$)).ti,ab. 51. (social adj (stories or narrative*)).ti,ab. 52. prompt\$.mp. 53. ((augment\$ or social) adj3 communicat\$).ti,ab. 54. (relationship adj develop\$).ti,ab. 55. (cognitive and (treat\$ or therap\$ or psychotherap\$)).mp. 56. cbt.ti,ab. 57. (sound adj3 (treat\$ or therap\$)).ti,ab. 58. (natural adj environment).ti,ab. 59. (activity adj schedule\$).ti,ab. 60. (direct adj instruct\$).ti,ab. 61. (giant adj step\$).ti,ab. 62. developmental individual difference.ti,ab. 63. option.ti,ab. 64. (sonrise or kaufman).ti,ab. 65. precision.ti,ab. |
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| | | <p>66. (social adj (skill* or pragmatic)).ti,ab. 67. hanen.ti,ab. 68. miller.ti,ab. 69. patterning\$.ti,ab. 70. philadelphia.ti,ab. 71. (dolman or delaccato).ti,ab. 72. (echange adj3 developement).ti,ab. 73. bartelemy.ti,ab. 74. (gentle adj teach\$.ti,ab. 75. denver.ti,ab. 76. leap.ti,ab. 77. (learning experiences adj alternative program).ti,ab. 78. pcdi.ti,ab. 79. princeton child development institute.ti,ab,af. 80. rutgers.ti,ab. 81. (natural adj teach\$.ti,ab. 82. milieu.ti,ab. 83. (neurodevelop\$ adj treat\$.ti,ab. 84. ndt.ti,ab. 85. walden.ti,ab. 86. adlerian.ti,ab. 87. theraplay.ti,ab. 88. Eden.ti,ab. 89. "early bird".ti,ab. 90. (video adj3 model\$.ti,ab. 91. (self adj3 (manage\$ or monitor\$)).ti,ab. 92. yale.ti,ab. 93. bancroft.ti,ab. 94. horizon.ti,ab. 95. (may adj institute).ti,ab. 96. task analysis.mp. 97. chaining.mp. 98. (restrict* adj2 repetitive pattern*).mp. 99. "symbol use".mp. 100. attention/ or joint attention.ti,ab. 101. exp "Reinforcement (Psychology)"/ 102. Conditioning, Operant/ 103. (differential adj2 reinforce*).ti,ab. 104. time delay.ti,ab. 105. exp peer group/ and exp teaching/ 106. (peer adj2 (mediat* or instruct* or teach* or learn* or tutor*)).ti,ab. 107. (function* adj2 behavio?r* adj assess*).ti,ab. 108. fba.ti,ab. 109. (stimulus adj3 (control or modif*)).ti,ab. 110. extinction.ti,ab. 111. (response interrupt* adj2 redirect*).mp. 112. RIRD.ti,ab. 113. exp Social Skills/ and group*.ti,ab. 114. (visual adj2 (script* or support* or aids or aid)).mp. 115. voca.ti,ab. 116. "Augmentative and alternative communication".kw. 117. "communication intervention".kw. 118. ((speech or communicat*) adj3 device*).ti,ab. 119. or/16-118 120. 15 and 119 121. limit 120 to yr="2006 -Current"</p> |
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Note:

†† “*”, “#”, and “?” are truncation characters that retrieve all possible suffix variations of the root word e.g. surg* retrieves surgery, surgical, surgeon, etc.

Appendix 2: Inclusion criteria form (step 1)

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| 1. Study Design: Systematic Review | | | |
| Does the study qualify as a systematic review? <input type="checkbox"/> In order to qualify the authors must have defined a search strategy to identify studies for inclusion and must have attempted to quantitatively or qualitatively analyze the data from primary studies (Note: The words 'systematic review' may not be the only descriptor to qualify. Meta-analysis and other reviews types could satisfy this criteria.) | Yes | No | Unsure |
| 2. Population: Diagnosis | | | |
| Does the study include individuals with a diagnosis that would now place them on the autism spectrum? (Note: The study does not have to exclusively include ASD.) <input type="checkbox"/> Autism Spectrum Disorder (ASD) <input type="checkbox"/> Autism <input type="checkbox"/> PDD – NOS <input type="checkbox"/> Atypical autism <input type="checkbox"/> Asperger’s Syndrome <input type="checkbox"/> Not yet diagnosed | Yes | No | Unsure |
| 3. Population: Age | | | |
| Does the study include children between the ages of 0 and 12 years old? | Yes | No | Unsure |
| 4. Intervention | | | |
| Is the review concerned with psychosocial interventions? (Not pharmacological, biological, or diet modification interventions.) | Yes | No | Unsure |
| 5. Outcomes | | | |
| Did the review report numerical/measurable improvements on at least one outcome? <input type="checkbox"/> Core symptoms of autism <input type="checkbox"/> Social communication (SC) <input type="checkbox"/> Restricted/repetitive behavior (RRB) <input type="checkbox"/> Both SC and RRB <input type="checkbox"/> Other (Psychological symptoms, cognitive skills, challenging behaviors, etc.) | Yes | No | Unsure |
| 6. Language | | | |
| Was the review written in English? | Yes | No | Unsure |

Final Decision

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| Should this study be included in the next stage? (Answer 'yes' if all of the above are yes.) | Yes | No | Unsure |
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Appendix 3: AMSTAR criteria form (Shea et al., 2007, p. 14; Shea et al., 2009, p. 1018)

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| <p>1. Was an ‘a priori’ design provided? The research question and inclusion criteria should be established before the conduct of the review.</p> | <p>Yes No Can’t answer</p> |
| <p>2. Was there duplicate study selection and data extraction? There should be at least two independent data extractors and a consensus procedure for disagreements should be in place.</p> | <p>Yes No Can’t answer</p> |
| <p>3. Was a comprehensive literature search performed? At least two electronic sources should be searched. The report must include years and databases used (e.g. Central, EMBASE, and MEDLINE). Key words and/or MESH terms must be stated and where feasible the search strategy should be provided. All searches should be supplemented by consulting current contents, reviews, textbooks, specialized registers, or experts in the particular field of study, and by reviewing the references in the studies found.</p> | <p>Yes No Can’t answer</p> |
| <p>4. Was the status of publication (i.e. grey literature) used as an inclusion criterion? The authors should state that they searched for reports regardless of their publication type. The authors should state whether or not they excluded any reports (from the systematic review), based on their publication status, language etc.</p> | <p>Yes No Can’t answer</p> |
| <p>5. Was a list of studies (included and excluded) provided? A list of included and excluded studies should be provided.</p> | <p>Yes No Can’t answer</p> |
| <p>6. Were the characteristics of the included studies provided? In an aggregated form such as a table, data from the original studies should be provided on the participants, interventions and outcomes. The ranges of characteristics in all the studies analyzed e.g. age, race, sex, relevant socioeconomic data, disease status, duration, severity, or other diseases should be reported.</p> | <p>Yes No Can’t answer</p> |
| <p>7. Was the scientific quality of the included studies assessed and documented? ‘A priori’ methods of assessment should be provided (e.g., for effectiveness studies if the author(s) chose to include only randomized, double-blind, placebo controlled studies, or allocation concealment as inclusion criteria); for other types of studies alternative items will be relevant.</p> | <p>Yes No Can’t answer</p> |

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| <p>8. Was the scientific quality of the included studies used appropriately in formulating conclusions? The results of the methodological rigor and scientific quality should be considered in the analysis and the conclusions of the review, and explicitly stated in formulating recommendations.</p> | <p>Yes No Can't answer</p> |
| <p>9. Were the methods used to combine the findings of studies appropriate? For the pooled results, a test should be done to ensure the studies were combinable, to assess their homogeneity (i.e. Chi-squared test for homogeneity, I^2). If heterogeneity exists a random effects model should be used and/or the clinical appropriateness of combining should be taken into consideration (i.e. is it sensible to combine?).</p> | <p>Yes No Can't answer</p> |
| <p>10. Was the likelihood of publication bias assessed? An assessment of publication bias should include a combination of graphical aids (e.g., funnel plot, other available tests) and/or statistical tests (e.g., Egger regression test).</p> | <p>Yes No Can't answer N/A</p> |
| <p>11. Was the conflict of interest stated? Potential sources of support should be clearly acknowledged in both the systematic review and the included studies.</p> | <p>Yes No Can't answer</p> |

Appendix 4: AMSTAR operationalization guide (Kitsiou et al., 2015, Appendix 2)

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| <p>Q1.</p> | <p>Was an a priori design provided?</p> <p>Yes: the authors refer to a published protocol, ethics approval, or pre-determined/a priori published research objectives e.g., SRs for which a research protocol is available (i.e. Cochrane), or SRs developed within specific research programs (HTA, U.S, Preventive Services Task Force, AHQR, NICE etc.)</p> <p>No: the authors do not refer to a protocol, ethics approval or pre-determined/a priori published research objectives and the SR is not developed within specific research programs such as Health Technology Assessment, NICE, AHQR, etc.</p> <p>Can't answer: the authors refer to a protocol or a set of a priori published research objectives, but the protocol cannot be retrieved or is no longer available.</p> |
| <p>Q2.</p> | <p>Was there duplicate study selection and data extraction?</p> <p>Yes: at least two people working independently selected studies for inclusion AND extracted the data from the included studies and the method was reported for reaching consensus if disagreements arose.</p> <p>No: the authors stated that both selection and extraction were performed by one person, or that only one of the two processes (i.e. data extraction or study selection) was performed by one person only instead of two (regardless if the second person checked data and/or selection for consistency).</p> <p>Can't answer: no information about it</p> |
| <p>Q3.</p> | <p>Was a comprehensive literature search performed?</p> <p>Yes: at least two electronic sources were searched (Cochrane register/Central counts as 2 sources); names of the databases, years searched and keywords and/or search strategy were provided; and the search was supplemented by one of the following strategies: searching of the reference lists of included studies or specialized registers; contacting experts; or searching for grey literature.</p> <p>No: only one database searched or used more than 2 sources but did not supplement searches with any of the above strategies.</p> <p>Can't answer: partial or no information reported (e.g. databases reported, but keywords or years missing)</p> |

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| <p>Q4.</p> | <p>Was status of publication (e.g. grey literature) used as an inclusion criterion?</p> <p>Yes: the authors explicitly stated that they did not exclude reports based on their language and that they searched for articles irrespective of publication type. If the authors do not explicitly state whether grey literature was used as an inclusion criterion but in the review there exist at least one included report/study that can be classified as non-English article, unpublished, or grey literature (e.g. dissertation, non-peer reviewed conference proceedings), then select Yes.</p> <p>No: authors stated that they excluded studies from the review (or did not search for studies) based on publication status, or language.</p> <p>Can't answer: no information are provided and no grey literature studies are included in the review</p> |
| <p>Q5.</p> | <p>Was a list of studies (included and excluded provided)?</p> <p>Yes: a list with the references of the included studies was provided <u>AND</u> a list with the references of the excluded studies (references) was provided either in the article or in a supplementary source (e.g. Appendix, online). The term excluded studies refers to those studies seriously considered by the review authors on the basis of title and/or abstract, but rejected after reading the body of the text.</p> <p>No: only the references of included studies provided; number of excluded studies along with a justification provided but reader can't link the justification with the exact reference/study that was excluded.</p> <p>Can't answer: partial information (e.g. all or some of the excluded studies were listed in the article's references but not in the text to allow the reader identify all of them)</p> |
| <p>Q6.</p> | <p>Were the characteristics of the included studies provided?</p> <p>Yes: data on participants, interventions and outcomes were provided, and the range of relevant characteristics reported either in a table or as narrative text.</p> <p>No: no information about the characteristics of the included studies provided. For example, review provided information about the interventions but not about the number of participants and the outcomes of interest of the study.</p> <p>Can't answer: partial information (e.g. only year of publication and intervention reported, or only some of the included studies described)</p> |

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| <p>Q7.</p> | <p>Was the scientific quality of the included studies assessed and reported?</p> <p>Yes: predetermined methods of assessing quality were reported i.e. a risk of bias or methodological quality assessment instrument/tool was used to critically appraise each study against the instrument’s criteria with some kind of result reported for <u>each</u> study.</p> <p>No: no quality assessment performed on the actual features of the individual studies (e.g. randomization, concealment of allocation, blinding of assessors, attrition, and/or other study design and implementation characteristics).</p> <p>Can’t answer: the authors stated that a quality assessment was done, but did not describe how it was performed (e.g. what instruments or criteria were used) and/or do not present the results of the assessment.</p> |
| <p>Q8.</p> | <p>Was the scientific quality of the included studies used appropriately in formulating conclusions?</p> <p>Yes: the quality (and limitations) of included studies was considered in the analysis (e.g. use of the GRADE system to rate the quality of evidence for each outcome) and/or the conclusions of the review (i.e. in making inferences about the effectiveness of home tele-monitoring). For example, authors might say “the results should be interpreted with caution due to the poor quality of the included studies”.</p> <p>No: quality assessment was not performed or was but the results were not considered throughout the analysis of the findings and/or at the end in formulating conclusions.</p> <p>Can’t answer: impact of quality of studies on results unclear or not used for conclusions.</p> |
| <p>Q9.</p> | <p>Were the methods used to combine the findings of studies appropriate?</p> <p>Yes: In SRs that pooled the results using meta-analysis, if statistical heterogeneity was assessed by means of a formal test (e.g., Chi-squared and/or I^2) and the results of these tests - along with other study aspects such as the clinical heterogeneity between the interventions - were used to inform the decision of the statistical model used (i.e. random or fixed). If statistical heterogeneity was present, (given the nature of home tele-monitoring interventions) a random effects model was used and/or the appropriateness of combining data was considered by the review authors. Yes, also, if in SRs that did not conduct meta-analysis, the authors made a statement regarding the inappropriateness of pooling data (e.g. highlighted issues about heterogeneity/variability between the studies) and thus, a qualitative synthesis was performed appropriately. That is, the authors summarized and synthesized the available evidence narratively according to a defined analysis plan and/or using appropriate qualitative methods and techniques (e.g. construction of common rubrics, content analysis, tabulation, groupings and clustering).</p> |

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| | <p>No: In SRs that pooled the results using meta-analysis, heterogeneity was present, but not discussed, fixed-effect model was used by default, and/or meta-analytic methods were used inappropriately (double counting of studies occurred, count data were treated as dichotomous, etc.). Note: if there is no heterogeneity present (e.g. $I^2=0\%$ or chi-square is non-significant, P is greater than 0.10), and review used fixed-effect model, score Yes because both fixed and random effects models yield the same results in this case. No, also, in SRs in which the authors did not attempt to combine findings into a meta-analysis and did not provide a statement regarding heterogeneity or the inappropriateness of combining findings.</p> <p>Can't answer: heterogeneity test result not reported or model (random vs. fixed) used to combine studies not specified.</p> |
| <p>Q10.</p> | <p>Was the likelihood of publication bias assessed?</p> <p>Yes: publication bias was explicitly considered and assessed. Funnel plots or other methods used (e.g. egger regression tests). (Note: if funnel plots are not presented as figures, but authors explicitly state that a publication bias assessment was performed and an interpretation of that test is provided, then score Yes.)</p> <p>No: In SRs that pooled the results using meta-analysis, publication bias was not assessed or no information about it was provided.</p> <p>Can't answer: mentioned or discussed it vaguely only in conclusions.</p> <p>Not applicable: SR was narrative/qualitative, not a meta-analysis</p> |
| <p>Q11.</p> | <p>Was the conflict of interest stated?</p> <p>Yes: conflict of interest and sources of support were clearly acknowledged in both the systematic review <u>AND</u> the included studies.</p> <p>No: conflict of interest and sources of funding were reported for the systematic review but not for the included primary studies or vice versa.</p> |

Appendix 5: AMSTAR raw data (Individual components of methodological quality)

| First author, year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | Total |
|---------------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|-----------|--------------|
| Kent-Walsh, 2015 | Y | Y | Y | Y | N | Y | Y | Y | Y | N | N | 8 |
| Schlosser, 2008 (AAC) | N | Y | Y | Y | Y | Y | Y | Y | Y | N/A | N | 8 |
| Thompson, 2014 | N | Y | Y | N | Y | Y | Y | Y | Y | Y | N | 8 |
| Costantino, 2014 | N | Y | Y | N | N | Y | Y | Y | Y | N/A | N | 6 |
| Mason, 2013 | N | Y | Y | N | N | Y | Y | Y | Y | N | N | 6 |
| Van Der Meer, 2010 | N | Y | Y | N | N | Y | Y | Y | Y | N/A | N | 6 |
| Akullian, 2009 | N | Y | Y | CA | N | Y | CA | Y | Y | N | N | 5 |
| Chung, 2012 | N | CA | Y | N | N | Y | Y | Y | Y | N/A | N | 5 |
| Flippin, 2010 | N | CA | Y | N | N | Y | Y | Y | Y | N | N | 5 |
| Ganz, 2012 (AAC1) | N | CA | Y | N | N | Y | Y | Y | Y | N | N | 5 |
| Hart, 2010 | N | Y | Y | N | CA | Y | CA | Y | Y | N | N | 5 |
| Knight, 2015 | N | CA | Y | N | N | Y | Y | Y | Y | N/A | N | 5 |
| Millar, 2006 | N | Y | Y | CA | N | Y | CA | Y | Y | N | N | 5 |
| Preston, 2009 | N | CA | Y | N | N | Y | Y | Y | Y | N/A | N | 5 |
| Ramdoss, 2011 | N | N | Y | N | N | Y | Y | Y | Y | N/A | N | 5 |
| Ramdoss, 2012 | N | N | Y | N | N | Y | Y | Y | Y | N/A | N | 5 |
| Ganz, 2011 | N | Y | Y | N | N | Y | N | N | Y | N | N | 4 |

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|----------------------|---|----|---|----|---|---|----|---|---|-----|---|---|
| Ganz, 2014 | N | Y | Y | N | N | Y | N | N | Y | N | N | 4 |
| Grynszpan, 2014 | N | Y | N | N | N | Y | N | N | Y | Y | N | 4 |
| Kagohara, 2010 | N | Y | Y | N | N | Y | CA | Y | N | N/A | N | 4 |
| Raulston, 2013 | N | Y | Y | N | N | Y | N | N | Y | N/A | N | 4 |
| Tincani, 2011 | N | Y | Y | N | N | Y | N | N | Y | N | N | 4 |
| Bellini, 2007 | N | Y | Y | N | N | Y | N | N | Y | N | N | 4 |
| Ganz, 2012 (PECS) | N | Y | N | N | N | Y | N | N | Y | N | N | 3 |
| Lequia, 2012 | N | Y | Y | N | N | Y | N | N | N | N/A | N | 3 |
| Lorah, 2015 | N | N | N | N | N | Y | Y | Y | N | N/A | N | 3 |
| Mason, 2012 | N | Y | N | N | N | Y | N | N | Y | N | N | 3 |
| Pennisi, 2016 | Y | CA | N | CA | N | Y | N | N | Y | N/A | N | 3 |
| Sulzer-Azaroff, 2009 | N | Y | Y | N | N | Y | N | N | N | N | N | 3 |
| Banda, 2008 | N | CA | Y | N | N | Y | N | N | N | N/A | N | 2 |
| Delano, 2007 | N | CA | Y | N | N | Y | N | N | N | N/A | N | 2 |
| Den Brok, 2015 | N | CA | Y | N | N | Y | N | N | N | N/A | N | 2 |
| Diehl, 2012 | N | CA | Y | N | N | Y | N | N | N | N/A | N | 2 |
| Shukla-Mehta, 2010 | N | CA | Y | N | N | Y | N | N | N | N/A | N | 2 |
| Tien, 2008 | N | CA | Y | N | N | Y | N | N | N | N/A | N | 2 |
| Wass, 2014 | N | CA | Y | CA | N | Y | N | N | N | N/A | N | 2 |

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|----------------------------|------|-------|-------|------|------|-------|-------|-------|-------|-------------|------|---|
| Aresti-Bartolome, 2014 | N | CA | N | N | N | Y | N | N | N | N/A | N | 1 |
| Acar, 2012 | N | CA | N | N | N | N | N | N | N | N/A | N | 0 |
| Totals per question | | | | | | | | | | | | |
| Total Y | 2 | 20 | 31 | 2 | 2 | 37 | 14 | 18 | 25 | 2 | 0 | |
| Total N | 36 | 3 | 7 | 32 | 35 | 1 | 20 | 20 | 13 | 13 | 38 | |
| Total CA | 0 | 15 | 0 | 4 | 1 | 0 | 4 | 0 | 0 | 0 | 0 | |
| Total N/A | | | | | | | | | | 23 | | |
| Percentage Y | 5.3% | 52.6% | 81.6% | 5.3% | 5.3% | 97.4% | 36.8% | 47.4% | 65.8% | 13.3% ** | 0.0% | |

*Y, yes; N, no; CA, can't answer; N/A, not applicable;

**N/A, only applicable for Q10 if a meta-analysis was performed; 13.3% was calculated from the number of studies that conducted meta-analyses (i.e., 15)