Case Study 1: An Evidence-Based Practice Review Report

Theme: Interventions Implemented by Parents

How effective are technology-assisted, parent Naturalistic Developmental Behavioural Interventions for supporting the development of social-communication skills in young children with Autism Spectrum Disorder?

Summary

There is increasing difficulty accessing social-communication interventions for young children with Autism Spectrum Disorder (ASD) due to financial and accessibility issues. There has been a growing evidence base for Naturalistic Developmental Behavioural Interventions (NDBIs) which aim to develop key skills in young children with ASD. Some of these NDBIs are being designed to enable parents to deliver the intervention to their own children with ASD. Technology has also been used to allow distance learning and coaching to occur. This review aims to establish how effective these technology-assisted, parent NDBIs are at improving social-communication skills in young children with ASD. Findings from six studies suggest that, despite the financial and accessibility benefits, there is currently limited evidence for the efficacy of technology-assisted, parent NDBIs in improving social-communication of young children with ASD.

Introduction

Autism Spectrum Disorder (ASD) is a pervasive, neurodevelopmental condition that emerges in early childhood. ASD affects individuals in different ways but it is characterised by difficulties in social communication and social interaction (American Psychiatric Association, 2013). Children with ASD often have difficulties with various aspects of social communication such as limited speech and difficulties with joint attention (Arciuli & Brock, 2014). These difficulties are often apparent in early childhood and can be the first symptoms of ASD noticed by parents (Stahmer et al., 2017). Early, intensive interventions are recommended to support the development of children with ASD (National Research Council, 2001).

Historically, behavioural interventions, such as Applied Behaviour Analysis (ABA) have dominated ASD literature and practice. These interventions employed behaviourist theories, such as operant conditioning (Skinner, 1938). This theory postulates that changes in skills occur as a result of positive reinforcement that helps to promote wanted behaviour. Initially, these interventions seemed to be effective in teaching new skills, however, this theory does not encapsulate the complexity of child development. Within interventions, children with ASD often struggled to generalise their new skills to different contexts, were over-reliant on prompts and often displayed avoidance behaviour (Schreibman et al., 2015). Developmental theories provide some understanding of these complexities. Various models of child development, such as Piaget's Stages of Development (1936), emphasised that children develop key skills through various stages and the importance of the child being an active learner (as cited in, Halpenny & Pettersen, 2013, p.

123). Thus, developmental interventions began to target precursors to language, such as joint attention and imitation through active participation. Other developmental theorists, such as Vygotsky (1987) highlighted the importance of social interactions for learning, therefore reciprocal exchanges were incorporated into interventions.

Recently, there has been an increasing amount of research suggesting the efficacy of Naturalistic Developmental Behavioural Interventions (NDBIs) aimed at improving key developmental skills, such as social-communication, in young children with ASD (Frost, 2018). NDBIs are based on the principles of behaviourism and developmental theories and consider the environment and experience of the learner.

There are a range of different NDBIs, each has a different theoretical emphasis but they all share several core components. Firstly, they are manualised and aimed at supporting young children with ASD develop key skills. NDBIs are all completed in natural settings as this helps develop skills that are pervasive across contexts (Schreibman et al., 2015). The environmental arrangement is manipulated so the child must interact in order to achieve a desired outcome. Activities are child-centred and are integrated into their typical daily routines, such as play (Frost, 2018). Child-initiated teaching episodes are also used, where the child's interests are utilised. Parents are involved to varying degrees, to focus on developing key skills via modelling, scaffolding and prompting (Schreibman et al., 2015).

The literature supporting NDBIs is developing, several studies have found they are effective in improving a range of social-communication skills in young

children with ASD including language (Dawson et al., 2010; Ingersoll, Meyer, Bonter, & Jelinek, 2012), joint attention (Lawton & Kasari, 2012) and imitation (Krupicz, 2014). However it is currently unclear what element of the intervention is effective, what dosage or timeframe is needed and for whom (Frost, 2018).

Several NDBIs have been developed or adapted to teach parents to deliver the intervention to their children, such as the parent version of the Early Start Denver Model (P-EDSM). Parental involvement can help improve child-parent interactions and can impact every day of a child's life (Oono, Honey, & McConachie, 2013). These parent NDBIs have had some promising results in improving key developmental skills, including social communication (Waddington, van der Meer, & Sigafoos, 2016). However, the evidence for these parent NDBIs is mixed and several studies investigating their efficacy lacked methodological quality.

Following the increasing availability of technology in everyday life, there has been an increased focus on providing technology-assisted interventions (Meadan, Meyer, Snodgrass, & Halle, 2013). In the last few years, there has been an increasing number of parent NDBIs being provided through technology, such as computers and tablets, in order to maximise the availability of interventions. Some of these parent NDBIs focused on providing self-directed resources, (e.g. Therapy Outcomes For You; TOBY) and others incorporated distance coaching from a trained therapist via video calls (e.g. ImPACT Online). There has been some evidence for their efficacy but research is in its infancy.

Rationale

Social-communication skills are vital for a range of functions and these have a huge impact on a child's life (Poon, Watson, Baranek, & Poe, 2012). They influence their ability to express themselves, learn and develop social relationships. Targeted social-communication interventions can have a long-term developmental effect on these skills (Gulsrud, Hellemann, Freeman, & Kasari, 2014). However, there is a shortage of available interventions for children with ASD, due to lack of funding and available services (Kogan et al., 2008).

Providing interventions that help parents develop their child's social-communication skills could be cost-effective and an ecologically valid way to increase access to ASD interventions. Furthermore, technology has the potential to provide portable, accessible and affordable interventions that can educate parents, enabling them to develop the social-communication skills of their children with ASD (Fletcher-Watson et al., 2016).

There is evidence emerging for the efficacy of technology-assisted, parent NDBIs but further understanding is required. It is essential that educational psychologists can support children with ASD and their families by recommending accessible, evidenced-based interventions that will support their needs. As a result of this, the following question will be addressed in this review:

How effective are technology-assisted, parent Naturalistic Developmental Behavioural Interventions for supporting the development of social-communication skills in young children with Autism Spectrum Disorder?

Critical Review of the Evidence

Systematic Literature Search

To establish the evidence base for technology-assisted, parent NDBIs a systematic literature search was completed in December 2018. The PsycINFO, ERIC and Medline databases were searched. Table 1 outlines the search terms used.

Table 1

Search Terms used in Databases

	Terms Used	Field
AND	technolog* OR computer OR app* OR iPad OR online OR tablet OR Internet OR web* OR telehealth OR teleconference OR email	In title
AND	parent* OR carer* OR guardian* OR mother* OR father*	Title, abstract or topic
AND	communic* OR interact* OR "social skills"	Title, abstract or topic
AND	ASD OR autis* OR "spectrum disorder" OR asperger*	Title, abstract or topic

Note. *Allows any ending of the word to be included e.g. technolog* would include technology, technologies, technological

This produced 224 records, 92 were removed as duplicates leaving 132 records. These were screened using predefined inclusion and exclusion criteria (Table 2). Based on their titles and abstracts, a further 103 were removed. The remaining 29 articles were reviewed for eligibility and 23 were excluded (Appendix A). The remaining six studies were used within this review (Table 3). Figure 1 documents the selection process using a flow diagram.

Table 2

Inclusion and Exclusion Criteria

	Factor	Inclusion Criteria	Exclusion Criteria	Rationale
1	Participants	Aged between 0 – 7 years	Aged over 7 years	The intervention primarily focuses on early intervention and are targeted at young children
2	Participants	Diagnosis of ASD	No diagnosis of ASD	The review question focuses on children with ASD, children with comorbid condition alongside ASD will also be included
3	Intervention	Technology-assisted	Not using technology	The review question is specifically looking at technology-assisted interventions
4	Intervention	Parent/carer involvement	No parent/carer involvement	The review question focuses on parent interventions
5	Intervention	Focuses on improving social-communication skills	Does not focus on improving social-communication skills	The review question focuses on interventions designed to improve social-communication skills
6	Intervention	A Naturalistic Developmental Behavioural Intervention	Not a Naturalistic Developmental Behavioural Intervention	The review question focuses on Naturalistic Developmental Behavioural Interventions
7	Outcomes	Measures social-communication skills	Does not measure social-communication skills	The review is looking at interventions that impact social-communication skills, studies that include other outcome measures alongside this can be included

|	Factor	Inclusion Criteria	Exclusion Criteria	Rationale
8	Setting	Conducted in a naturalistic setting	Delivered in a clinical setting	The review question is specifically exploring the use of remote parent interventions in naturalistic settings
9	Location	Conducted in an Organisation for Economic Co-Operation and Development (OECD) country	Conducted in a country that is not an OECD member	OECD countries have similar democratic and economics features and similar educational systems to the UK therefore the findings would be more generalisable to the UK population
10	Study design	Quantitative studies	Qualitative studies	This will allow a measure of the effectiveness of the interventions and enable comparisons between studies, studies that include mixed methods can be included
11	Study design	The study contains primary empirical data	The study does not contain primary empirical data	This review is examining primary evidence, secondary data will not be used
12	Date of publication	Published since 2014	Any studies published in or before 2014	As technology changes quickly, it is important to investigate recent developments i.e. in the last five years
13	Type of publication	Peer-reviewed journal articles	Literature that is published in any other format	These studies have been evaluated by experts and have met quality standards
14	Language	Written in English	Not written in English	The researcher is monolingual and the cost and time constraints prevent translation
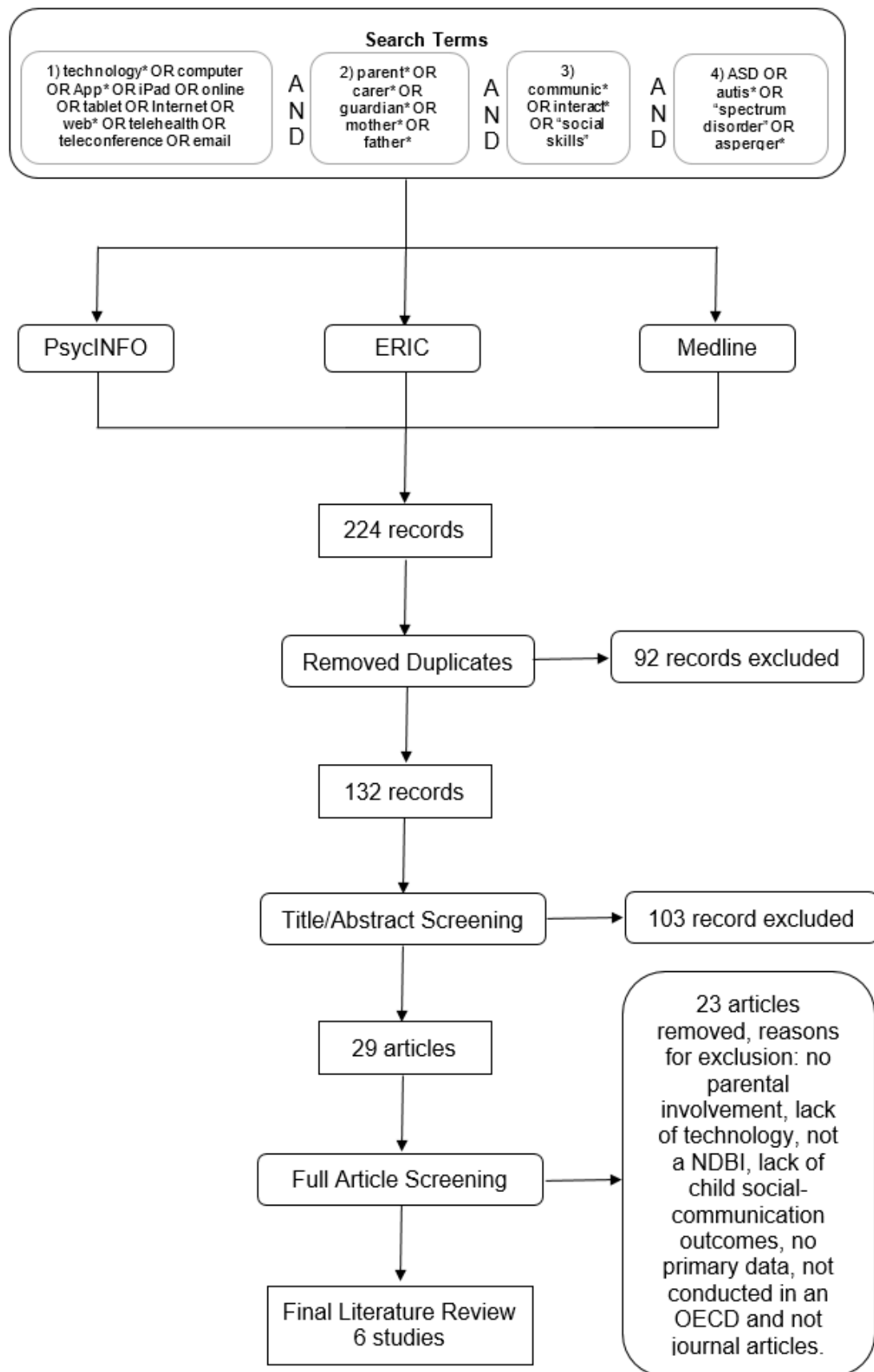
Figure 1. Flow diagram of the selection process

Table 3

Full References of Included studies

Full reference
Ingersoll, B., Wainer, A. L., Berger, N. I., Pickard, K. E., & Bonter, N. (2016). Comparison of a Self-Directed and Therapist-Assisted Telehealth Parent-Mediated Intervention for Children with ASD: A Pilot RCT. *Journal of Autism and Developmental Disorders*, *46*(7), 2275–2284.
Parsons, D., Cordier, R., Vaz, S., & Lee, H. C. (2018). Parent-Mediated Intervention Training Delivered Remotely for Children With Autism Spectrum Disorder Living Outside of Urban Areas: Systematic Review. *Journal of Medical Internet Research*, *19*(8), e198.
Vismara, L. A., McCormick, C. E. B., Wagner, A. L., Monlux, K., Nadhan, A., & Young, G. S. (2018). Telehealth Parent Training in the Early Start Denver Model: Results from a Randomized Controlled Study. *Focus on Autism and Other Developmental Disabilities*, *33*(2), 67–79.
Vismara, L. A., McCormick, C., Young, G. S., Nadhan, A., & Monlux, K. (2013). Preliminary Findings of a Telehealth Approach to Parent Training in Autism. *Journal of Autism and Developmental Disorders*, *43*(12), 2953–2969.
Wainer, A. L., & Ingersoll, B. (2015). Increasing access to an ASD imitation intervention via a telehealth parent training program. *Journal of Autism and Developmental Disorders*, *45*(12), 3877–3890.
Whitehouse, A. J. O., Granich, J., Alvares, G., Busacca, M., Cooper, M. N., Dass, A., … Anderson, A. (2017). A randomised controlled trial of an iPad-based application to complement early behavioural intervention in Autism Spectrum Disorder. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, *58*(9), 1042-1052.

Mapping the Field

Six studies were identified within the systematic literature search that met the inclusion criteria. The key features of each study have been outlined in Table 4.

Table 4

Summary of Included Studies: Mapping the Field

Author	Country	Sample	Design	Control Group	Communication Measures	Intervention	Delivery Method	Technology
Ingersoll et al, 2016	USA	28 children with ASD between 19-73 months	Small scale randomised control trial 6 months intervention with follow up at 3 months	Self-Directed used of intervention	Parent-reported: a) MacArthur-Bates Communicative Development Inventory (CDI) b) Vineland Adaptive Behavior Scale (VABS-II) Observed: a) Language Targets	ImPACT Online with therapist-assistance	Therapist-assisted via video-conferencing 24 x 30 min coaching sessions	Materials accessed via a password-protected website Video-conferencing delivered via Skype
Parsons et al., 2018	Rural Australia	60 children with ASD between 24 and 70 months	Randomised control trial 3 months intervention with follow up at 3 & 6 months	Waitlisted therapy-as-usual	Parent-reported: a) Communication and Symbolic Behaviour Scales Developmental Profile Caregiver Questionnaire (CSBS) Observed: a) Mullen Scale of Early Learning (MSEL) b) Pragmatic Observation Measure (POM)	Therapeutic Outcomes By You (TOBY)	Self-directed 20 minutes once-per-day recommended	Mobile application accessed via iPad
Vismara et al., 2018	USA	24 children with ASD between 18-48 months	Small scale randomised control trial 3 months intervention with follow up at 3 months	Active	Observed: a) Spontaneous utterances b) Imitative functional c) Unprompted non-verbal joint attention	Parents in the Early Start Denver Model parent coaching programme (P-ESDM)	Therapist-assisted via video-conferencing 12 x 90 minute coaching sessions	Materials and program features accessed via a password-protected website Video-conferencing delivered via Skype

Author	Country	Sample	Design	Control Group	Communication Measures	Intervention	Delivery Method	Technology
Vismara et al., 2013	USA	8 children with ASD between 18-45 months	Small N multiple baseline 3 months intervention with 3 follow up sessions	N/A	Parent-reported: a) MacArthur-Bates Communicative Development Inventory (CDI) Observed: a) Verbal utterances b) Non-verbal joint attention	Parents in the Early Start Denver Model parent coaching programme (P-ESDM)	Therapist-assisted via video-conferencing 12 x 90 minute coaching sessions	Materials and program features accessed via a password-protected website Video-conferencing
Wainer & Ingersoll, 2015	USA	5 children with ASD between 24-75 months	Small N multiple baseline Two treatment conditions with 3 follow up sessions at 1 & 3 months	N/A	Observed: a) Spontaneous imitation	Reciprocal imitation training (RIT)	Self-directed condition Coaching condition 3 x 30 minute coaching sessions	Self-directed condition completed via a secure website Coaching via video calling software
Whitehouse et al., 2017	Australia	80 children with ASD with an average age of 40.56 months	Randomised control trial 6 months intervention with no follow up	Waitlisted therapy-as-usual	Parent-reported: a) Autism Treatment Evaluation Checklist (ATEC) b) Vineland Adaptive Behavior Scale (VABS-II) c) MacArthur-Bates Communicative Development Inventory (CDI) d) Communication and Symbolic Behaviour Scales Developmental Profile Caregiver Questionnaire (CSBS) Observed: a) Mullen Scale of Early Learning (MSEL)	Therapeutic Outcomes By You (TOBY)	Self-directed 20 minutes once-per-day recommended	Mobile application accessed via iPad

Weight of Evidence

Gough's Weight of Evidence (WoE) framework (2007) was used to appraise the studies. Three sets of criteria were used: (1) methodological quality (WoE A), (2) methodological relevance to the review question (WOE B) and (3) topic relevance (WoE C). An average of these ratings provided an overall WoE rating (WoE D).

Within this review, four studies used group designs and two used a small N design, consequently, two different protocols were used to assess WoE A. For group designs, the Kratochwill protocol (2003) and for small N designs the Horner et al., (2005) coding protocol was used (Appendix B). For the purpose of this review, ratings of less than 1.9 were considered 'low', ratings between 1.9 – 2.4 'medium' and ratings above 2.4 'high'. Table 5 documents the WoE ratings for each criterion.

Table 5

Weight of Evidence Ratings

Authors	WoE A Methodological Quality	WoE B Methodological Relevance	WoE C Topic Relevance	WoE D Overall Score
Ingersoll, Wainer, Berger, Pickard & Bonter (2016)	1.83 (Low)	3.00 (High)	2.67 (High)	2.50 (High)
Parsons, Cordier, Vaz & Lee (2018)	1.83 (Low)	3.00 (High)	2.00 (Medium)	2.28 (Medium)
Vismara, McCormick, Wagner, Monlux & Nadhan (2018)	1.67 (Low)	3.00 (High)	1.50 (Low)	2.06 (Medium)
Vismara, McCormick, Young, Nadhan & Monlux (2013)	2.14 (Medium)	1.00 (Low)	1.17 (Low)	1.44 (Low)
Wainer & Ingersoll (2015)	2.14 (Medium)	1.00 (Low)	1.83 (Low)	1.66 (Low)
Whitehouse et al., (2018)	1.66 (Low)	3.00 (High)	2.00 (Medium)	2.22 (Medium)

Participants

In this review, there were 205 participants, 112 were involved in a NDBI and 93 of these were controls. The child participants were between 19 – 75 months and had a clinical diagnosis of ASD, one study only reported mean age (Whitehouse et al., 2018).

Most of the studies included both males and females, however only one had a gender ratio similar to that documented in the DSM-5 for children with ASD of four males to one female (Vismara et al., 2018). Two studies did not report this statistic (Vismara et al., 2013; Wainer & Ingersoll, 2015) and the remaining studies had a higher proportion of males. This has an impact on the generalisability of the studies' findings as the samples are not representative of the wider ASD population, therefore this has been reflected in the WoE C ratings.

Four studies were completed in the USA (Ingersoll et al., 2016; Vismara et al., 2013; 2018; Wainer & Ingersoll, 2015) and two in Australia (Parsons et al., 2018; Whitehouse et al., 2018). None of the studies were completed in the UK, which may limit generalisability to the UK population, however this is minimised as the USA and Australia are members of the Organisation of Economic Co-Operation and Development (OECD), which suggests these countries have a similar democratic and economic features and similar education systems. As all the studies were completed outside of the UK and in OECD countries, this factor did not impact on WoE.

The majority of the studies used convenience sampling to recruit participants. Some participants were recruited from websites (Vismara et al., 2013; 2018;

Whitehouse et al., 2018), local intervention centres (Vismara et al., 2013; 2018; Whitehouse et al., 2018), referrals from diagnosing professionals or from previous involvement in research trials (Whitehouse et al., 2018). This type of sampling limits the generalisability of the findings as the participants may not be representative of the population (Barker, Pistrang, & Elliott, 2016). One study used snowballing to recruit their sample (Parsons et al., 2018), this also has implications for generalisability as the participants may be unusually similar to each other and therefore not representative of the wider population (Barker at al., 2016).

Social-communication difficulties were part of the inclusion criteria for two studies and some information regarding these needs was provided (Ingersoll et al., 2016; Wainer & Ingersoll, 2015). The remaining studies may have assumed these needs were present based on their ASD diagnosis. Failing to include this information makes it difficult to establish for whom the interventions will be most effective (Frost, 2018). Consequently, the studies that included information about their participants' social-communication needs received higher WoE C ratings.

In addition, two of the first authors (Vismara & Ingersoll) were involved in the development of the interventions used in their studies (ImPACT Online and P-ESDM). They also receive royalties from the sale of the materials linked to their interventions, this is a conflict of interest and could create an element of bias within their research, to promote the sale of their interventions for personal gain. However, these conflicts of interest were declared within the articles and other researchers were involved in the studies, which may mediate any bias.

It was also unclear whether both studies by Vismara and colleagues used the same data (2013; 2018). The first study stated the participants included in the study were part of a larger randomised control trial (RCT), the author was contacted to confirm this information but it remains inconclusive. Duplicate publication can produce bias within a review, especially if the results are positive (Fairfield, Harrison, & Wigmore, 2017). However, as the results from these studies differ, both were analysed, but should be treated with caution.

Design

There was some variation in the designs employed in these studies. Four studies were RCTs (Ingersoll et al., 2016; Parsons et al., 2018; Vismara et al., 2018; Whitehouse et al., 2018). Three of these studies compared a NDBI with a control group and one compared self-directed parental use of the NDBI with therapist-assisted parental use of NDBI (Ingersoll et al., 2016). One study used an 'active' control group, where the participants received video conferencing and access to online content without the NDBI elements (Vismara et al., 2018). This type of control group is more acceptable ethically and the findings indicate whether any effects are a result of the NDBI elements, this was given a higher WoE A rating.

Cohen (1992) recommended that power analyses should be completed to determine an appropriate sample size for group intervention studies. Two of the studies reported completing a power analysis to establish how many participants were needed for their studies (Parsons et al., 2018; Whitehouse et al., 2018). Both studies had sufficient participants to achieve a medium effect size. However, the remaining two studies did not report completing a

power analysis (Ingersoll et al., 2016; Vismara et al., 2018). Post-hoc power analyses based on a medium effect size revealed that they were underpowered. One of these studies did not find a significant effect, as it was underpowered this may have resulted in a Type II error, where no effect is report when one does exist (Field, 2013).

Two studies used multiple baseline designs with a small number of participants (Vismara et al. 2013; Wainer & Ingersoll, 2015). Small N research designs, such as multiple baseline, are considered rigorous, scientific methodology and useful for educational research (Horner et al., 2005). However, they lack generalisability due to their small samples and it is more difficult to establish whether any effects are due to the intervention as they do not use a control group. Furthermore, Petticrew and Roberts (2003) argue that when investigating the efficacy of an intervention (as in this review) RCTs provide more useful evidence. This, therefore, was reflected in WoE B, RCTs received a rating of 3, whereas, small N designs received a rating of 1.

Five of the studies included a follow up procedure after the intervention had finished, these varied between studies. Two studies completed one at three months (Ingersoll et al., 2016; Vismara et al., 2018), one completed two follow ups at three and six months (Parsons et al., 2018) and the small N designs both had three follow up sessions (Vismara et al., 2013; Wainer & Ingersoll, 2015). Completing a follow up procedure provides information about the longer-term effects of the intervention. One study did not include a follow up, this contributed to the lower WoE A rating given (Whitehouse et al., 2018).

Intervention

Four different NDBIs were used in the studies in the review, with a range of focuses, delivery modes and technology. Two studies used P-EDSM which focuses on improving a range of key skills including social-communication (Vismara et al., 2013; 2018). As the intervention focuses on a range of key skills, it will be more difficult to establish the active ingredients responsible for change in social-communication skills. This has been reflected in WoE C ratings. The interventions in the remaining studies were all focused on improving social-communication skills.

The mode of delivery also varied, two studies provided parents with self-directed learning materials to enable parents to deliver the NDBI independently (Parsons et al., 2018; Whitehouse et al., 2018). As this would allow the intervention to be more widely accessed and at a lower cost, these were rated more highly in WoE C. However, both studies produced only minimal or small effects on social-communication skills, which may indicate therapist support is necessary for parents to implement NDBI effectively.

The remaining studies had therapist input in addition to self-directed materials, the findings of these studies were mixed. One comparing the difference between self-directed participants and therapist-assisted participants found both groups of children made gains in their social-communication skills but the therapist-assisted group made greater improvements, particularly on a measure of social skills (Ingersoll et al., 2018). These results suggest that a self-directed NDBI can improve social-communication skills but therapist support provides greater gains. Wainer and Ingersoll (2015) used two phases

of intervention, first a self-directed condition followed by therapist coaching, this study found great variability in the effects of the intervention and no clear pattern of improvement was found after either condition. The interventions in the remaining two studies incorporated therapist coaching via video-conferencing alongside self-directed materials throughout the intervention phases. One revealed no significant difference between the intervention and the control group (Vismara et al., 2018). One showed a small effect on verbal utterances and small-medium effect on parent reported social-communication measures (Vismara et al., 2018). This variability in findings suggests that it unclear whether therapist involvement mediates the effects of NDBIs.

The interventions also used a range of technology, four studies used a secure-website accessed via computer and two studies used mobile applications assessed via tablets. The software also had variable features as some included email functions, forums for communication with parents and interactive games for the child. As both the hardware and software differed, this creates a lack of consistency between the studies which may have influenced effects of the NDBIs and makes it difficult to draw firm conclusions across the studies.

Fidelity within the studies was also variable; as this review focuses on parent NBDIs, both therapist fidelity and parent fidelity were considered. All the studies that incorporated therapist coaching within the intervention phases reported high levels of therapist fidelity using inter-observer agreement. However, there was considerable difference between parent fidelity. Two studies measured fidelity to dosage by analysing time spent on the intervention

platform and found dosage was considerably below what was recommended (Parsons et al., 2018; Whitehouse et al., 2018). These studies received a lower WoE C rating as this does not consider the implementation of NDBIs methods by parents. The remaining studies the researchers coded videos of parent-child interactions to establish parental implementation fidelity. Fidelity within these studies was still problematic, in one study the majority of parents did not reach a level accurate of implementation post-intervention and in the small N studies, only 80-88% of parents met fidelity at some point in the intervention (Vismara et al., 2013; Wainer & Ingersoll, 2015). One study found that all parents in the self-direct and therapist-assisted groups made improvements in fidelity (Ingersoll et al., 2016). However, the therapist-assisted group was significantly higher post-intervention but there was no difference between the groups at the follow up.

Interestingly, studies that included therapist coaching showed lower rates of drop out. Drop outs were also higher in the control groups within these studies, whereas, drop out was higher in the treatment group within self-directed interventions. This suggests that therapist involvement helped both fidelity and attrition.

Outcome Measures & Findings

A range of outcome measures were used within the studies, including various parent self-report questionnaires, assessments completed by the researchers and observational assessments.

Four different standardised parent-report questionnaires pertaining to communication were used: (1) the MacArthur-Bates Communicative

Development Inventory, (2) the Vineland Adaptive Behavior Scale, (3) the Autism Treatment Evaluation Checklist and (4) the Communication and Symbolic Behavior Scales Developmental Profile Caregiver Questionnaire. All these measures are considered to have an acceptable reliability (Barker et al., 2016). The Mullen Scale of Early Learning was used by two studies, which allowed researchers to assess various cognitive abilities including expressive and receptive language. This has high inter-observer reliability and it is considered a valid measure for assessing developmental skills in children with ASD (Akshoomoff, 2006). Four studies used quantifiable behavioural observations to evaluate social-communication skills. Each study measured reliability and reported high inter-observer agreements.

Four studies included at least two assessments from different sources, which allowed for triangulation of the data, this was considered in their WoE A ratings (Ingersoll et al., 2016; Parsons et al., 2018; Vismara et al., 2013; Whitehouse et al., 2018).

To establish the efficacy of an intervention, it is important to calculate effect sizes to analyse the magnitude of the effects. One study reported partial-eta squared effect sizes, these were converted into Cohen's *d* for comparison and have been reported in Table 6 (Ingersoll et al., 2016). The Cohen's standardised mean difference (SMD) was calculated using pre- and post-intervention scores for two RCTs (Parsons et al., 2018; Whitehouse et al., 2018). A within-person change over time pre- and post-intervention (Becker, 1988) was calculated for one of the multiple baseline, small N study (Vismara et al., 2013). These effect sizes are reported in Table 7 and Table 8. It was not

possible to calculate effect sizes for the remaining two studies as they did not report post intervention scores for their social communication measures, this was reflected in their WoE C rating (Vismara et al., 2018; Wainer & Ingersoll, 2015).

To interpret these effect sizes, Cohen's *d* interpretations were used where 0.2 is considered a 'small effect', 0.5 'medium' and 0.8 represents a 'large effect'. The findings from the studies are variable, only one study found one large effect and one medium effect showing increases in individual language targets and social skills following ImPACT Online (Ingersoll et al., 2016). This study also received the highest overall WoE rating so these findings should be given more weighting. One study also found medium effects at follow up after completion of Reciprocal Imitation Training (RIT), suggesting there may be a delayed impact on vocabulary production and comprehension (Wainer & Ingersoll, 2015). However, this study received the lowest overall WoE rating due to its limited methodological and topic relevance and the findings should be considered with caution. Furthermore, the remaining studies revealed small or minimal effects on all social-communication measures, suggesting there is limited impact of these technology-assisted, parent NDBIs.

Table 6

Effect Size for Social-Communication Skills for RCTs with an Intervention + Therapist and Self-Directed Intervention

Author	Measures	Intervention + Therapist			Self-Directed Intervention			Effect size					WoE D
		N	Pre M (SD)	Post M (SD)	N	Pre M (SD)	Post M (SD)	F	p	n^2_p	d	Descriptor	
Ingersoll et al., 2016 Intervention	Language Targets	13	.65 (.52)	1.80 (1.00)	14	1.36 (1.53)	1.95 (1.08)	2.84	.10	0.10	0.68	Medium	2.67
	CDI Vocabulary		185.114 (202.17)	243.64 (237.94)		144.69 (146.21)	210.38 (187.46)	1.17	>.05	0.05	0.43	Small	
	VABS Communication		70.29 (11.28)	77.36 (13.79)		71.50 (15.57)	75.33 (12.40)	0.68	>.05	0.30	0.33	Small	
	VABS Social Skills		70.00 (6.96)	75.71 (9.07)		71.00 (8.05)	70.00 (7.56)	4.94	<.05	0.17	0.89	Large	

Vineland Adaptive Behaviour Scales 2nd edition (VABS)
MacArthur-Bates Communicative Development Inventory (CDI)

Table 7

Effect Size for Social-Communication Skills for Small N designs

Author	Measure	Mean				Effect Size				WoE D
		N	Pre (SD)	Post (SD)	Follow Up	SMD Post	Descriptor	SMD Follow up	Descriptor	
Vismara at al. 2013	Functional Verbal Utterances	8	2.97 (1.83)	3.50 (2.51)	-	0.29	Small	-	-	1.49
	Joint Attention Initiations		1.67 (1.07)	1.67 (1.21)	-	0	No effect	-	-	
	CDI Vocabulary		111.87 (156.03)	163.88 (156.03)	213.88 (155.08)	0.33	Small	0.65	Medium	
	CDI Comprehension		224.37 (133.25)	284.88 (141.53)	314.88 (94.16)	0.45	Small	0.68	Medium	

MacArthur-Bates Communicative Development Inventory (CDI)
Within-person change was used to work out effect size (Becker, 1988)
- No data available

Table 8

Effect Size for Social-Communication Skills for RTCs with an Intervention and Waitlist Control

Author	Measures	Intervention			Control			Effect size			WoE D
		N	Pre M (SD)	Post M (SD)	N	Pre M (SD)	Post M (SD)	p	d	Descriptor	
Parsons al., 2018	MSEL Receptive Language	21	68.1 (26.00)	72.1 (32.84)	27	64.9 (23.75)	71.6 (26.98)	0.56	0.17	Minimal effect	2.00
	MSEL Expressive Language		56.5 (22.03)	70.9 (27.97)		63.1 (22.28)	67.5 (22.75)	0.33	0.29	Small	
	CSBC Social Domain		33.7 (6.79)	36.2 (7.07)		28.1 (9.20)	31.0 (8.40)	0.39	0.25	Small	
	CSBC Speech Domain		32.5 (8.61)	32.3 (10.67)		30.8 (8.61)	32.4 (10.76)	0.66	0.12	Minimal effect	
Whitehouse et al., 2018	ATEC Communication[a]	39	14.31 (8.47)	10.15 (8.58)	36	16.00 (6.78)	9.31 (6.86)	0.01	0.11	Minimal effect	2.00
	MSEL Receptive Language		25.00 (15.82)	34.11 (18.19)		25.13 (12.99)	32.75 (15.42)	0.89	0.08	Minimal effect	
	MSEL Expressive Language		26.76 (15.56)	31.68 (17.41)		26.26 (12.30)	31.00 (16.20)	0.53	0.04	Minimal effect	
	VABS Communication	38	75.38 (18.73)	83.43 (19.46)	35	72.31 (14.60)	76.25 (13.36)	0.00	0.43	Small	
	CDI Vocabulary		174.03 (150.63)	263.76 (153.75)		176.12 (148.38)	244.10 (140.67)	0.90	0.13	Minimal effect	
	CDI Comprehension		231.13 (141.27)	303.48 (115.16)		246.97 (136.40)	287.83 (128.32)	0.97	0.13	Minimal effect	
	CDI Total Gestures		37.58 (13.69)	48.04 (9.25)		35.62 (13.25)	42.10 (14.60)	0.88	0.49	Small	
	CSBS Social Domain		13.28 (4.69)	15.25 (5.19)		13.75 (5.44)	16.04 (5.65)	0.45	-0.14	Minimal negative effect	
	CSBS Speech Domain		10.10 (3.45)	11.69 (3.30)		9.97 (4.09)	11.54 (3.68)	0.46	0.04	Minimal effect	

Mullen Scale of Early Learning (MSEL)
Communication and Symbolic Behavior Scales Developmental Profile Caregiver Questionnaire (CSBC)
MacArthur-Bates Communicative Development Inventory (CDI)
Autism Treatment Evaluation checklist (ATEC)
[a] higher score indicates greater level of difficulty

Conclusion and Recommendations

Currently, the evidence for the effectiveness of technology-assisted, parent NDBIs for improving social-communication skills in young children with ASD is limited. Only one large effect was found in social skills and two medium effects were found for language and vocabulary (Ingersoll et al., 2016; Vismara et al., 2013). However, the remaining studies found small or minimal effects across all social-communication measures and two studies did not report enough data to calculate effect size (Vismara et al., 2018; Wainer & Ingersoll, 2015).

The heterogeneity of the studies made synthesising the findings difficult as the intervention focus, delivery, technology and outcome measures varied considerably across the studies, therefore it is difficult to establish any reasons for these mixed findings. One study showed that a NDBI with therapist coaching was more effective than self-directed intervention (Ingersoll et al., 2016). Some support for this is provided by Vismara and colleagues (2013), as a medium effect was found after a NDBI with therapist coaching. These findings were not replicated in all studies with therapist coaching but lower attrition rates and increased fidelity were found, suggesting therapist-assisted NDBIs may be more effective than self-directed NDBIs for supporting children with ASD.

There were several limitations highlighted within these studies. Firstly, none of the studies were completed within the UK and the samples used were small, reducing the generalisability of the findings and limiting power to detect an effect (Field, 2013). Due to nature of the sampling, participants were often not representative of the wider population (e.g. demographics and education).

Also, parental fidelity was low in several of the studies, which may have limited the effectiveness of the intervention. Two studies investigated this relationship and found a correlation between parent fidelity and improvements in child social-communication outcomes. This suggests parental fidelity to intervention implementation is important to improve child social-communication outcomes. Finally, two authors involved in four of the studies, had a conflict of interest, which may have influenced their findings.

Despite the variable findings and methodological issues, technology-assisted, parent NDBIs do have some benefits. Several of the studies, reported parental benefits such as reduced stress and that parents responses suggested the interventions have strong social validity. The use of these interventions could have the potential to increase therapeutic provision for children with ASD. Educational psychologists should however note the limited evidence base for technology-assisted, parent NDBIs when recommending interventions for young children with ASD.

Further research should aim to avoid the methodological issues highlighted above. Firstly, larger RCTs, with more representative samples should be completed, this will allow more generalisability and the possible mediators and moderators of the effects could be investigated. This may help establish the active ingredients within the intervention and decipher who benefits the most from NDBIs. It is important to conduct further studies in the UK to establish whether results can be generalised. Future research should report all outcome data and focus on developing greater unification regarding outcome measures as this will help to compare the effects of NDBIs more easily. Within the

majority of these studies, the number of males participating was disproportionate and several studies also reported a considerably lower representation of fathers participating. Research investigating girls with ASD and fathers would suggest whether the findings are generalisable to these groups.

As parent NDBIs are still emerging and technology is constantly developing, further research is needed to develop our understanding of the active ingredients of these interventions and to provide more evidence of their efficacy. This will provide educational psychologists with greater evidence to make informed decisions about the implementation of technology-assisted, parent NDBIs.

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Wainer, A. L., Pickard, K., & Ingersoll, B. (2017). Using Web-Based Instruction, Brief Workshops, and Remote Consultation to Teach Community-Based Providers a Parent-Mediated Intervention. *Journal of Child and Family Studies*, *26*, 1592–1602.

Whalen, C., Moss, D., Ilan, A. B., Vaupel, M., Fielding, P., MacDonald, K., … Symon, J. (2010). Efficacy of TeachTown: Basics computer-assisted intervention for the Intensive Comprehensive Autism Program in Los Angeles Unified School District. *Autism, 14*(3), 179–197.

Whitehouse, A. J. O., Granich, J., Alvares, G., Busacca, M., Cooper, M. N., Dass, A., … Anderson, A. (2017). A randomised controlled trial of an iPad-based application to complement early behavioural intervention in Autism Spectrum Disorder. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, *58*(9), 1042-1052.

Wojciechowski, A., & Al-Musawi, R. (2017). Assisstive technology application for enhancing social and language skills of young children with autism. *Multimedia Tools and Applications, 76*(4), 5419–5439.

Appendices

Appendix A – Excluded Studies

Table 9

Studies excluded during full-text screening

Study	Reason(s) for Exclusion
Artoni, S., Bastiani, L., Buzzi, M. C., Buzzi, M., Curzio, O., Pelagatti, S., & Senette, C. (2018). Technology-enhanced ABA intervention in children with autism: a pilot study. *Universal Access in the Information Society*, *17*(1), 191–210.	2. The intervention is not delivered primarily by parents 3. The intervention is not delivered solely via technology
Aziz, M. Z. A., Abdullah, S. A. C., Adnan, S. F. S., & Mazalan, L. (2014). Educational App for Children with Autism Spectrum Disorders (ASDs). In Yussof, H (Ed.), *Medical and Rehabiliation Robotics and Instrumentation (MRRI2013)* (Vol. 42, pp. 70–77)	4. The intervention is not delivered primarily by parents 6. The intervention is not NDBI 7. There are no social-communication outcomes

Study	Reason(s) for Exclusion
	13. This is not a journal article
Beamish, W., Meadows, D., Prime, M., & Fisher, B. (2017). Parent and PreService Teacher Partnering in a Technology-Based Home Intervention: Preliminary Findings. In *Proceedings of the 2017 International Conference on Advanced Technologies Enhancing Education (ICAT2E 2017)* (Vol. 68, pp. 14–17).	6. The intervention is not NDBI 7. There are no social-communication outcomes 13. This is not a journal article
Cesario, V., Rodrigues, J., Li, H., Wu, I., & Nisi, V. (2016). Crescendo: Routine Learning App for Children with Autism Spectrum Disorders. In *Proceeding of the 15th Internetional Confernece on Interaction Design and Children (IDC2016)* (pp. 571–576).	4. The intervention is not delivered by parents 6. The intervention is not NDBI 7. There are no social-communication outcomes 13. This is not a journal article
Cipolla, D. S. (2013). An investigation of the effects of a computer-based intervention on the social skills of children with autism. *Dissertation Abstracts International Section A: Humanities and Social Sciences*, *73*(11–A(E)	4. The intervention is not delivered primarily by parents 6. The intervention is not NDBI 13. This is not a journal article
Fletcher-Watson, S., Petrou, A., Scott-Barrett, J., Dicks, P., Graham, C., O'Hare, A., … McConachie, H. (2016). A trial of an iPad™ intervention targeting social communication skills in children with autism. *Autism*, *20*(7), 771–782.	6. The intervention is not NDBI

Study	Reason(s) for Exclusion
Granich, J., Dass, A., Busacca, M., Moore, D., Anderson, A., Venkatesh, S., … Whitehouse, A. J. O. (2016). Randomised controlled trial of an iPad based early intervention for autism: TOBY playpad study protocol. *BMC Pediatrics*, *16*(1), 167.	10. This has no results as it is a trial protocol
Ibanez, L. V, Kobak, K., Swanson, A., Wallace, L., Warren, Z., & Stone Lisa V. (2018). Enhancing interactions during daily routines: A randomized controlled trial of a web-based tutorial for parents of young children with ASD. *Autism Research, 11*(1), 667-678.	5. The intervention does not primarily focus on improving social-communication outcomes 6. The intervention is not NDBI
Ingersoll, B., Shannon, K., Berger, N., Pickard, K., & Holtz, B. (2017). Self-Directed Telehealth Parent-Mediated Intervention for Children With Autism Spectrum Disorder: Examination of the Potential Reach and Utilization in Community Settings. *Journal of Medical Internet Research, 19*(7), e248.	7. There are no social-communication outcomes
Law, G. C., Neihart, M., & Dutt, A. (2018). The use of behavior modeling training in a mobile app parent training program to improve functional communication of young	9. The study is not conducted in an OECD country

children with autism spectrum disorder. *Autism : The International Journal of Research and Practice*, *22*(4), 424–439.

Study	Reason(s) for Exclusion
Manap, A. A., Dehkordi, S. R., Rias, R. M., & Sardan, N. A. (2013). Computer Game Approach Focusing on Social Communication Skills for Children with Autism Spectrum Disorder: An Initial Study. In Gaol, FL and Soewito, B and Bououdina, M and Chen, MS (Ed.), *Proceedings of the 2013 International Conference on Computer Graphics, Visualization and Game Technology* (Vol. 53, pp. 26–31).	6. The intervention is not NDBI 7. There are no social-communication outcomes 13. This is not a journal article
McDuffie, A., Machalicek, W., Oakes, A., Haebig, E., Weismer, S. E., & Abbeduto, L. (2013). Distance Video-Teleconferencing in Early Intervention: Pilot Study of a Naturalistic Parent-Implemented Language Intervention. *Topics in Early Childhood Special Education*, *33*(3), 172–185.	6. The intervention is not NDBI 7. There are no social-communication outcomes
Meadan, H., & Daczewitz, M. E. (2015). Internet-based intervention training for parents of young children with disabilities: a promising service-delivery model. *Early Child Devlopment and Care*, *185*(1), 155–169.	11. This study does not include primary data
Meadan, H., Meyer, L. E., Snodgrass, M. R., & Halle, J. W. (2013). Coaching Parents of Young Children with Autism in Rural Areas Using Internet-Based Technologies: A Pilot Program. *Rural Special Education Quarterly*, *32*(3), 3–10.	10. No results were reported for child outcomes
Mohan, V., Kunnath, S. K., Philip, V. S., Mohan, L. S., & Thampi, N. (2017). Capitalizing on technology for developing communication skills in autism spectrum disorder: a single case study. *Disability and Rehabilitation. Assistive Technology*, 1–7.	6. The intervention is not NDBI

Study	Reason(s) for Exclusion
Ramdoss, S., Machalicek, W., Rispoli, M., Mulloy, A., Lang, R., & O'Reilly, M. (2012). Computer-based interventions to improve social and emotional skills in individuals with autism spectrum disorders: A systematic review. *Developmental Neurorehabilitation*, *15*(2), 119–135.	4. The intervention is not delivered by parents 6. The intervention is not NDBI
Simacek, J., Dimian, A. F., & McComas, J. J. (2017). Communication Intervention for Young Children with Severe Neurodevelopmental Disabilities Via Telehealth. *Journal of Autism and Developmental Disorders*, *47*(3), 744–767.	6. The intervention is not NDBI
Snodgrass, M. R., Chung, M. Y., Biller, M. F., Appel, K. E., Meadan, H., & Halle, J. W. (2017). Telepractice in Speech-Language Therapy: The Use of Online Technologies for Parent Training and Coaching. *Communication Disorders Quarterly*, *38*(4), 242–254.	6. The intervention is not NDBI 7. There are no social-communication outcomes
Spencer, T. D., & Higbee, T. S. (2012). Using Transfer of Stimulus Control Technology to Promote Generalization and Spontaneity of Language. *Focus on Autism and Other Developmental Disabilities*, *27*(4), 225–236.	4. The intervention is not delivered by parents 6. The intervention is not NDBI

Suess, A. N., Wacker, D. P., Schwartz, J. E., Lustig, N., & Detrick, J. (2016). Preliminary evidence on the use of telehealth in an outpatient behavior clinic. *Journal of Applied Behavior Analysis*, *49*(3), 686–692.	6. The intervention is not NDBI 7. There are no social-communication outcomes
Wainer, A. L., Pickard, K., & Ingersoll, B. (2017). Using Web-Based Instruction, Brief Workshops, and Remote Consultation to Teach Community-Based Providers a Parent-Mediated Intervention. *Journal of Child and Family Studies*, *26*, 1592–1602.	7. There are no social-communication outcomes
Whalen, C., Moss, D., Ilan, A. B., Vaupel, M., Fielding, P., MacDonald, K., … Symon, J. (2010). Efficacy of TeachTown: Basics computer-assisted intervention for the Intensive Comprehensive Autism Program in Los Angeles Unified School District. *Autism*, *14*(3), 179–197.	4. The intervention is not delivered by parents
Wojciechowski, A., & Al-Musawi, R. (2017). Assisstive technology application for enhancing social and language skills of young children with autism. *Multimedia Tools and Applications*, *76*(4), 5419–5439.	6. The intervention is not NDBI

Appendix B - Weight of Evidence Ratings

Weight of Evidence A – Methodological Quality

Two WoE protocols were used to evaluate WoE A, these evaluated the methodological quality of each study. Kratochwill (2003) was used to assess group design and Horner et al., (2005) for single-subject designs.

Group Studies

Ingersoll, Wainer, Berger, Pickard & Bonter (2016), Parsons, Cordier, Vaz & Lee (2018), Vismara, McCormick, Wagner, Monlux & Nadhan (2018) and Whitehouse et al., (2018) were evaluated using the Kratochwill (2003) coding protocol. This coding protocol was adapted for this review, the revisions and rationale are explained in Table 10. An average of the six criteria was calculated to provide an overall WoE A rating.

Table 10

Adaptions to Kratochwill (2003) Group Study Coding Protocol

Aspects Removed/Revised	Rationale
Outcomes	The review will analyse the child outcomes and effect sizes of each study therefore this section has been removed
Identifiable Components	The components of each intervention and their link to communication skills for children with ASD will be considered within the review therefore this section has been removed
Replication	To meet inclusion criteria for this review, all studies were completed in the home therefore this section has been removed
Fidelity	As this review focuses on parent mediated interventions, therapist fidelity will be considered in WoE A and parental fidelity will be considered in WoE C

Table 11

Weight of Evidence A: Rating Criteria for Group Studies

A. Measurement
The study uses multi-method of data collection (at least two assessment methods)
The study uses multiple sources of data collection (at least two sources)
The measures used are valid (well-known, standardised or norm-referenced)
Rating
3 = All child outcome measure have reliability of 0.7 or above and all of the of the criteria are fulfilled
2 = At least 75% child outcome measure have reliability of 0.7 or above and two of the criteria are fulfilled

1 = At least 50% child outcome measure have reliability of 0.7 or above and one of the criteria are fulfilled

0 = Child outcome measure did not produce reliable scores AND/OR none of these above criteria are fulfilled

B. Comparison Group

Group equivalence has been established

The comparison group were counterbalanced by change agent

There is equivalent mortality with low attrition

Rating

3 = The comparison group is 'active' (e.g. typical intervention, attention placebo, intervention element placebo, alternative interventions, pharmacotherapy) and all of the criteria are fulfilled

2 = The comparison group must be 'no intervention group' (e.g. no intervention, waitlist/delayed intervention, minimal contact) and two of the criteria are fulfilled

1 = There is a comparison group and one of the criteria is fulfilled

0 = Minimal efforts were made to ensure group equivalence

C. Statistical Analysis

The study uses an appropriate unit of analysis

The familywise/experimenter wise error rate has been controlled for (when applicable)

A sufficiently large N has been used

Rating

3 = At least 75% of the child outcomes are statistically significant and all of criteria are fulfilled

2 = At least 50% of the child outcomes are statistically significant and two of the criteria are fulfilled

1 = At least 25% of the child outcomes are statistically significant and one of the criteria is fulfilled

0 = Less than 25% of child outcomes were statistically significant or none of the criteria were met

D. Educational/Clinical Significance

Categorical diagnosis data

Outcomes assessed via continuous variables

Subjective evaluation

Social comparison

Rating

3 = At least three of the criteria

2 = Two of the criteria

1 = One of the criteria

0 = None of the criteria
E. Fidelity

Ongoing supervision/consultation

Coding sessions
Rating

3 = 'Manualised' either have a detailed written account of the exact procedure or formal training of the exact procedure must be provided and two of the criteria

2 = 'Manualised' either have a broad written overview of the principles and a description of the intervention phases or formal/informal training involving an overview of the principles and interventions phases and one of the criteria

1 = Use of a manual or one of the above criteria

0 = No evidence of treatment fidelity
F. Follow Up Assessment

Majority of participants included from the original samples

Similar measures used to original outcome measures
Rating

3 = Multiple follow up assessments and all of the criteria

2 = At least one follow up assessment and all of the criteria

1 = At least one follow up assessment and one of the criteria

0 = No follow up assessment

Table 12

Weight of Evidence A: Ratings for Group Studies

Authors	Dimensions						Overall WoE A
	A	B	C	D	E	F	

Ingersoll, Wainer, Berger, Pickard & Bonter (2016)	2	2	1	2	2	2	1.83
Parsons, Cordier, Vaz & Lee (2018)	3	1	1	3	2	1	1.83
Vismara, McCormick, Wagner, Monlux & Nadhan (2018)	0	3	1	2	2	2	1.67
Whitehouse et al., (2018)	3	2	1	2	2	0	1.66

Small N Studies

Vismara et al., (2013) and Wainer & Ingersoll (2015) were evaluated using the Horner et al., (2005) coding protocol. An average of the seven criteria was calculated to provide an overall WoE A rating.

Table 13

Weight of Evidence A: Rating Criteria for Small N Studies

A. Description of Participants
Participants are described with sufficient detail to allow others to select individuals with similar characteristics (e.g. age, gender, disability, diagnosis)
The process for selecting participants is described with replicable precision
Critical features of the physical setting are described with sufficient precision to allow replication

Rating
3 = All of the criteria are fulfilled
2 = Two of the criteria are fulfilled
1 = One of the criteria is fulfilled
0 = None of the criteria are fulfilled

B. Dependent Variable
Dependent variables are described with operational precision
Each dependent variable is measured with a procedure that generates a quantifiable index

Measurement of the dependent variable is valid and described with replicable precision

Dependent variables are measured repeatedly over time

Data are collected on the reliability or interobserver agreement associated with each dependent variable, and IOA levels meet minimal standards

Rating
3 = All of the criteria are fulfilled
2 = Three to four of the criteria are fulfilled
1 = One or two of the criteria are fulfilled
0 = None of the criteria are fulfilled
C. Independent Variable

Independent variable is described with replicable precision

Independent variable is systematically manipulated and under the control of the experimenter

There is overt measurement of the fidelity of the implementation for the independent variable

Rating
3 = All of the criteria are fulfilled
2 = Two of the criteria are fulfilled
1 = One of the criteria is fulfilled
0 = None of the criteria are fulfilled
D. Baseline

The study includes a baseline phase that provides repeated measurement of the dependent variable(s)

The study establishes a pattern of responding that can be used to predict the pattern of future performance, if introduction or manipulation of the independent variable did not occur

Baseline conditions are described with replicable precision

Rating
3 = All of the criteria are fulfilled

2 = Two of the criteria are fulfilled

1 = One of the criteria is fulfilled

0 = None of the criteria are fulfilled

E. Experimental Control/Internal Validity

The design provides at least three demonstrations of experimental effect at three different points in time

The design controls for common threats to internal validity (e.g. permits elimination of rival hypotheses)

The results document a pattern that demonstrates experimental control

Rating

3 = All of the criteria are fulfilled

2 = Two of the criteria are fulfilled

1 = One of the criteria is fulfilled

0 = None of the criteria are fulfilled

F. External Validity

Experimental effects are replicated across participants and settings to establish external validity

Rating

3 = Experimental effects are replicated across 3 or more participants and in a unique setting

2 = Experimental effects are replicated across 3 or more participants

1 = Experimental effects are replicated across at least 2 participants

0 = Experimental effects are replicated with less than 2 participants

G. Social Validity

The dependent variable is socially important

The magnitude of change in the dependent variable resulting from the intervention is socially important

Implementation of the independent variable is practical and cost effective

Social validity is enhanced by the implementation of the independent variable over extended time periods, by typical intervention agents, in typical physical and social contexts

Rating
3 = All of the criteria are fulfilled
2 = Two or three of the criteria are fulfilled
1 = One of the criteria are fulfilled
0 = None of the criteria are fulfilled

Table 14

Weight of Evidence A: Ratings for Small N Studies

Authors	Dimensions							Overall
	A	B	C	D	E	F	G	WoE A
Vismara, McCormick, Young, Nadhan & Monlux (2013)	2	3	3	2	1	2	2	2.14
Wainer & Ingersoll (2015)	2	3	2	2	2	2	3	2.14

Weight of Evidence B – Methodological Relevance

WoE B evaluated how relevant the design utilised in each study was for evaluating the review question.

Table 15

Weight of Evidence B: Rating Criterion

Ratings	Rationale
A. Study Design	
3 = Randomised control trials and randomised experimental design	Informed by Petticrew and Roberts (2003) who investigated studies most suited to questions about 'effectiveness'
2 = Quasi-experimental design and cohort studies	
1 = Non-experimental and all other study designs	

Table 16

Weight of Evidence B: Ratings

Authors	Overall WoE B
Ingersoll, Wainer, Berger, Pickard & Bonter (2016)	3
Parsons, Cordier, Vaz & Lee (2018)	3
Vismara, McCormick, Wagner, Monlux & Nadhan (2018)	3
Vismara, McCormick, Young, Nadhan & Monlux (2013)	1
Wainer & Ingersoll (2015)	1
Whitehouse et al., (2018)	3

Weight of Evidence C – Topic Relevance

WoE C assessed the topic relevance to the review question using seven criteria. The rationale for including each criteria is outlined in Table 17. An average of the seven criteria was calculated to provide an overall WoE C rating.

Table 17

Weight of Evidence C: Rating Criteria

Ratings	Rationale
A. Purpose of the Intervention	
3 = The intervention mainly focuses on improving social-communication skills, both verbal and nonverbal 2 = The intervention focuses on improving social-communication skills either verbal or non-verbal	The review focused on whether technology-assisted, parent mediated NDBI improve the social-communication skills of young children with ASD,

1 = The intervention focuses on a range of skills including social-communication skills 0 = There is no focus on social-communication skills	therefore, an intervention focused on social-communication skills is important for this

B. Delivery of the Intervention

3 = Parents deliver this intervention fully with minimal input from therapists/researchers 2 = Parents are provided with coaching from therapist/researchers to enable them to deliver the intervention 1 = Parents and therapists/researchers co-deliver the intervention 0 = Therapists deliver the whole intervention	This review focused on technology-assisted, parent mediated NDBI and the input of therapist increases the cost and availability of the intervention

C. ASD and Social-Communication Needs

3 = Participants were selected for the study based on their social-communication needs and some information about their needs are reported 2 = Participants were selected based on their social-communication needs 1 = ADOS scores were reported 0 = No information is provided about the participants social-communication needs or ADOS scores	This review analyses interventions for children with ASD, as ASD population is very heterogeneous it is important to understand what interventions are effective for whom by establishing the symptoms prior to completing the intervention

D. Gender Ratio

3 = Both boys and girls took part in the study at a 4:1 ratio suggested in the DSM-5 (2013) 2 = Both boys and girls took part in the study 1= The study was single sex, either only boys or only girls	ASD is not a gender specific diagnosis, the research would be more representative if it includes both boys and girls at a similar ratio to the wider population

0 = The study does not disclose the number of boys and girls involved or actively excludes one sex

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E. Outcome Measures

3 = The primary measures focus on social-communication skills (verbal or nonverbal) and pre, post and follow up scores are reported for all communication measures	The review focused on whether technology-assisted, parent mediated NDBI improve the social-communication skills of young children with ASD, therefore, measures of communication skills are vital for this and it is important to report pre, post and follow up measures in order to establish the effectiveness of the interventions
2 = The study includes some measure of social-communication skills (verbal or nonverbal) and pre and post scores are reported for all communication measures	
1 = The study includes some measure of social-communication skills (verbal or nonverbal) and pre and post scores are reported for some communication measures	
0 = The study does not report pre and post scores for any social-communication measures	

F. Parental Fidelity

3 = Parental fidelity to implementation of the intervention is measured and inter-rater reliability is completed	As this review focuses on parent mediated interventions it is important to consider parental fidelity, this will indicate whether the effects of the intervention can be attributed to the intervention itself
2 = Parental fidelity to implementation of the intervention is measured	
1 = Dosage fidelity is measure via technology usage statistics	
0 = Parental fidelity has not been measured	

Table 18

Weight of Evidence C: Ratings

Authors	Dimensions						Overall WoE C
	A	B	C	D	E	F	
Ingersoll, Wainer, Berger, Pickard & Bonter (2016)	3	2	3	2	3	3	2.67

Parsons, Cordier, Vaz & Lee (2018)	3	3	0	2	3	1	2.00
Vismara, McCormick, Wagner, Monlux & Nadhan (2018)	1	2	0	3	0	3	1.50
Vismara, McCormick, Young, Nadhan & Monlux (2013)	1	2	0	0	2	3	1.33
Wainer & Ingersoll (2015)	2	2	3	0	1	3	1.83
Whitehouse et al., (2018)	3	3	1	2	2	1	2.00

Weight of Evidence D – Overall rating

Table 19

Weight of Evidence D: Overall Ratings

Authors	WoE A – Methodological Quality	WoE B – Methodological Relevance	WoE C – Topic Relevance	WoE D – Overall Score
Ingersoll, Wainer, Berger, Pickard & Bonter (2016)	1.83	3.00	2.67	2.50
Parsons, Cordier, Vaz & Lee (2018)	1.83	3.00	2.00	2.28
Vismara, McCormick, Wagner, Monlux & Nadhan (2018)	1.67	3.00	1.50	2.06
Vismara, McCormick, Young, Nadhan & Monlux (2013)	2.14	1.00	1.33	1.49
Wainer & Ingersoll (2015)	2.14	1.00	1.83	1.66
Whitehouse et al., (2018)	1.66	3.00	2.00	2.22

Weightings: high > 2.4, medium = 1.9 - 2.4, low = <1.9

Appendix C – Coding Protocols

Coding Protocol for Group Designs – Ingersoll et al., 2016

[Adapted from 'Task Force on Evidence-Based Interventions in School Psychology, American Psychology Association', Kratochwill, T.R. (2003)]

Full Study Reference in proper format:

Ingersoll, B., Wainer, A. L., Berger, N. I., Pickard, K. E., & Bonter, N. (2016). Comparison of a Self-Directed and Therapist-Assisted Telehealth Parent-Mediated Intervention for Children with ASD: A Pilot RCT. *Journal of Autism and Developmental Disorders, 46*(7), 2275–2284.

Intervention name and description:

ImPACT is an intervention aimed at providing parents the skills to develop the social communication of their young children with ASD. It uses an interactive, behavioural approach within naturalistic settings. This intervention was provided on online through 12 self-taught modules and some participants also received telehealth support from a trained therapist via video-conferencing.

Type of Publication:

☐Book/Monograph

☒Journal Article

☐Book Chapter

☐Other (specify):

i.   General Characteristics

A. General Design Characteristics

A1. Random assignment designs (if random design, select one of the following)

☐Completely randomised design

☒Randomised block design (between-subject variation)

☐Randomised block design (within-subject variation)

☐Randomised hierarchical design

A2. Nonrandomised designs (if nonrandom design, select one of the following)

☐Nonrandomised design

☐Nonrandomised block design (between-subject variation)

☐Nonrandomised block design (within-subject variation)

☐Nonrandomised hierarchical design

☐Optional coding of Quasi-experimental designs

A3. Overall confidence of judgements on how participants were assigned (select one of the following)

☐Very low (little bias)

☐Low (guess)

☐Moderate (weak inference)

☒High (strong inference)

☐Very high (explicitly stated)

☐N/A

☐Unknown/unable to code

B. Participants

B1. Total sample size (start of the study): 28

B2. Intervention group sample size: 15

B3. Control group sample size: 13

C. Type of Program

☐Universal prevention program

☐Selective prevention program

☐Targeted prevention program

☒Intervention/treatment

☐Unknown

D. Stage of Program

☐Model/demonstration program

☒Early stage program

☐Established/institutionalised programs

☐Unknown

E. Concurrent of Historical Intervention Exposure

☐Current exposure

☐Prior exposure

☒Unknown

ii. Key Features for Coding Studies and Rating Level of Evidence/Support

 (3 = strong evidence   2 = promising evidence   1 = weak evidence   0 = no evidence)

A. Measurement

A1. The study uses outcome measures that produce reliable scores for the majority of the primary outcomes

☐Yes

☐No

☒Unknown/unable to code

A2. The study uses multi-method of data collection (at least two assessment methods)

☒Yes

☐No

☐N/A

☐Unknown/unable to code

A3. The study uses multiple sources of data collection (at least two sources)

☒Yes

☐No

☐N/A

☐Unknown/unable to code

A4. The measures used are valid (well-known, standardised or norm-referenced)

☐Yes validated with the specific target group

☒In part, validated for the general population

☐No

☐Unknown/unable to code

Rating for Measurement: ☐3 ☒2 ☐1 ☐0

B. Comparison Group

B1. Type of comparison group (select one of the following)

☐Typical contact

☐Typical contact (other) specify:

☐Attention placebo

☐Intervention elements placebo

☒Alternative intervention

☐Pharmacotherapy

☐No intervention

☐Waitlist/delayed intervention

☐Minimal contact

☐Unable to identify comparison group

B2. Overall confidence in judgements of type of comparison group (select one of the following)

☐Very low (little bias)

☐Low (guess)

☐Moderate (weak inference)

☐High (strong inference)

☒Very high (explicitly stated)

☐N/A

☐Unknown/unable to code

B3. Counterbalancing by Change Agents

☐By change agent

☐Statistical

☐Other

☒Unknown/unable to code

B4. Group Equivalence Established

☒Random assignment

☐Post hoc matched set

☐Statistical matching

☐Post hoc test for group equivalence

B5. Equivalent Mortality

☐Low attrition (less than 20% for post)

☐Low attrition (less than 30% for follow up)

☒Intent to intervene analysis carried out

Rating for Comparison Group: ☐3 ☒2 ☐1 ☐0

C. Appropriate Statistical Analysis

Analysis 1: ANOVA

☒ Appropriate unit of analysis
☐ Familywise/experimenter wise error rate controlled when applicable
☐ Sufficiently large N

Rating for Statistical Analysis: ☐3 ☐2 ☒1 ☐0

D. Educational/Clinical Significance

Study must provide evidence in support if the clinical significance for:

☒ Categorical diagnosis data
☒ Outcomes assessed via continuous variables
☐ Subjective evaluation
☐ Social comparison

Rating for Educational/Clinical Significance: ☐ 3 ☒ 2 ☐ 1 ☐ 0

E. Fidelity

E1. Evidence of Acceptable Adherence

☐ Ongoing supervision/consultation
☒ Coding sessions
☐ Audio/video tapes implementation

E2. Manualisation (select all that apply)

☐ Written material involving a detailed account of exact procedures and sequence in which they are to be used
☐ Formal training session that includes a detailed account of the exact procedures and the sequence they are to be used
☒ Written material involving an overview of broad principles and a description of the intervention phases
☒ Formal or informal training session involving an overview of broad principles and a description of the intervention phase

E3. Adaption procedure are specified ☐ yes ☐ no ☒ unknown

Rating for Fidelity: ☐ **3** ☒ **2** ☐ **1** ☐ **0**

F. Follow up Assessment

F1. Timing of follow up assessment, specify: 3 months

F2. Number of participants included in the follow up assessment, specify: 24

Rating for Follow Up Assessment: ☐ **3** ☒ **2** ☐ **1** ☐ **0**

Summary of Evidence

Indicator	Overall evidence rating (0-3)
A. Measurement	2
B. Comparison Group	2
C. Appropriate Statistical Analysis	1
D. Educational/Clinical Significance	2
E. Fidelity	2
F. Follow Up Assessment	2

Total	11
WoE A	1.83

Coding Protocol for Small N Designs – Vismara et al., 2013

[Adapted from 'The Use of Single Subject Research to Identify Evidence-Based Practice Special Education' Horner, Carr, Halle, McGee & Wolery (2005)]

Full Study Reference in proper format:

Vismara, L. A., McCormick, C., Young, G. S., Nadhan, A., & Monlux, K. (2013). Preliminary Findings of a Telehealth Approach to Parent Training in Autism. *Journal of Autism and Developmental Disorders*, *43*(12), 2953–2969.

Intervention name and description:

A parent model of the Early Start Denver Model (P-ESDM) delivered via telehealth. The program was accessed via two-way, live video conferencing and a self-guided website aimed at providing parents with the skills to deliver ESDM through ten topic. ESDM is based on applied behaviour analysis and targets a range skills across different areas of development in young children with ASD. This telehealth, parent version sought to provide parents with the skills to work on these areas of development with their own children in their homes.

Type of Publication:

☐Book/Monograph

☒Journal Article

☐Book Chapter

☐Other (specify):

A. Description of Participants

A1. Participants are described with sufficient detail to allow others to select individuals with similar characteristics (e.g. age, gender, disability, diagnosis)

☐Yes

☒No

A2. The process for selecting participants is described with replicable precision

☒Yes

☐No

A3. Critical features of the physical setting are described with sufficient precision to allow replication

☒Yes

☐No

Rating for Description of Participants: ☐3 ☒2 ☐1 ☐0

B. Dependent Variable

B1. The dependent variables are described with operational precision

☒Yes

☐No

B2. Each dependent variable is measured with a procedure that generates a quantifiable index

☒Yes

☐No

B3. Measurement of the dependent variable is valid and described with replicable precision

☒Yes

☐No

B4. The dependent variables are measured repeatedly over time

☒Yes

☐No

B5. Data are collected on reliability or interobserver agreement associated with each dependent variable and IOA levels meet minimal standards

☒Yes

☐No

Rating for Dependent Variable: ☒3 ☐2 ☐1 ☐0

C. Independent Variable
C1. The independent variable is described with replicable precision

☒Yes

☐No

C2. The independent variable is systemically manipulated and under the control of the experimenter

☒Yes

☐No

C3. There is overt measurement of the fidelity of the implementation of the independent variable

☒Yes

☐No

Rating for Independent Variable: ☒3 ☐2 ☐1 ☐0

D. Baseline

D1. The study includes a baseline phases that provides repeated measurement of the dependent variable(s)

☒Yes

☐No

D2. The study establishes a pattern of responding that can be used to predict the pattern of future performance, if introduction or manipulation of the independent variable didn't occur

☐Yes

☒No

Baseline conditions are described with replicable precision

☒Yes

☐No

Rating for Baseline: ☐3 ☒2 ☐1 ☐0

E. Experimental Control/Internal Validity

E1. The design provides at least three demonstrations of experimental effect at three different points in time

☒Yes

☐No

E2. The design controls for common threats to internal validity e.g. permits elimination of rival hypotheses

☐Yes

☒No

E3. The results document a pattern that demonstrates experimental control

☐Yes

☒No

Rating for Experimental Control/Internal Validity: ☐3 ☐2 ☒1 ☐0

F. External Validity
F1. Experimental effects (select one)

☐Experimental effects are replicated across three or more participants and in a unique setting

☒Experimental effect are replicated across three or more participants

☐Experimental effect are replicated across at least two participants

☐Experimental effects are replicated with less than 2 participants

Rating for External Validity: ☐3 ☒2 ☐1 ☐0

G. Social Validity

G1. The dependent variable is socially important

☒Yes

☐No

G2. The magnitude of change in the dependent variable resulting from the intervention is socially important

☒Yes

☐No

G3. Implementation of the independent variable is practical and cost effective

☐Yes

☒No

G4. Social validity is enhanced by implementation of the independent variable over extended time periods, by typical intervention agents, in typical physical and social contexts

☐Yes

☒No

Rating for Social Validity: ☐3 ☒2 ☐1 ☐0

Dimension	Rating
Description of Participants	2
Dependent Variable	3

Independent Variable	3
Baseline	2
Experimental Control/Internal Validity	1
External Validity	2
Social Validity	2

Total	15
Overall WoE A	2.14