Critical Review:
Are technology-based interventions more effective than traditional interventions at teaching children with Autism Spectrum Disorder (ASD) social communication skills?

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This critical review examines the current evidence comparing the effectiveness of technology-based interventions to non-technology-based interventions in teaching social-communication skills to children with autism spectrum disorder (ASD). A search of the literature yielded nine relevant papers, of which eight were single-subject designs and one was a randomized controlled trial design. These studies provided suggestive evidence that technology-based interventions are an effective means to teach social-communication skills to children with ASD. Conclusions about the comparative effectiveness of technology-based and non-technology based interventions could not be made due to several limitations within the studies. Clinical implications and recommendations for future research are discussed.

Introduction

According to the Centers for Disease Control and Prevention (2014), roughly 1 in every 68 children are identified with Autism Spectrum Disorders (ASD), making it one of the fastest growing developmental disorders globally. Social communication is an area of functioning that is particularly difficult for children with ASD (Cihak, Smith, Cornett, & Coleman, 2012) and is a common intervention goal. Typical social communication targets for children with ASD include early skills such as joint attention, appropriate play, gesturing, and sharing (Jones, Carr, & Feeley, 2006), as well more complex skills like requesting, social commenting, and responding appropriately to the actions or emotions of others (Miller & Bugnariu, 2016).

An increasing number of technology-based interventions are available for use with children with ASD, including computer or tablet applications, video-modeling, virtual reality, and robotic therapy. The use of technology makes it possible to create predictable environments and offer multi-sensory stimulation (Aresti-Bartolome & Garcia-Zapirain, 2014), factors that make technology highly motivating and reinforcing for individuals with ASD. Technology-based interventions are economical in terms of resources and materials (Malmberg, Charlop & Gershfeld, 2015), and thus, may offer a cost-effective solution to the rising number of individuals diagnosed with ASD.

Studies exploring the effectiveness of technology-based social communication interventions for children with ASD have yielded mixed findings. Very few studies have compared the effectiveness of technology-based interventions to that of more traditional interventions that do not utilize technology. Therefore, it is critical to evaluate the evidence base for technology-based interventions to guide clinical decision-making regarding the most effective therapy delivery method to teach social communication skills to children with ASD.

Objectives

The primary objective of this paper is to critically evaluate current literature addressing the effectiveness of technology-based interventions in improving the social communication skills of children with ASD. The secondary objective of this review is to provide evidence-based clinical implications for the use of technology-based interventions in teaching social communication skills to this population.

Methods

Search Strategy

Relevant research studies were found through an online search of the Scopus and PsycINFO databases. The following key terms were used: (autism) OR (ASD) AND (computer*) OR (video) OR (robot*) OR (tech*) OR (virtual).

Selection Criteria

Research studies that compared the effectiveness of technology-based interventions to non-technology-based interventions to teach social skills to children with ASD were selected for inclusion. Additionally, participants could not be diagnosed with any other neurodevelopmental disorders in addition to ASD.

Data Collection

Nine articles that were consistent with the aforementioned selection criteria were found and

included in this review. Eight studies employed single-subject designs and one used randomized controlled design.

Results

Single Subject Designs:

Charlop-Christy, Le, & Freeman (2000) conducted a multiple baseline design across five children with ASD (7 – 11 years) to compare the effectiveness of video modeling with in-vivo modeling to teach social skills. Recruitment and inclusion criteria were well specified. All participants were diagnosed according to gold standard measures. The children participated in between 2 and 12 modeling sessions, in which they watched either a video or in-vivo model of a target social behaviour. Afterwards, each participant was given the opportunity to demonstrate the target behaviour while completing a randomly assigned social task. Correct and incorrect responses were recorded by therapists and observers blinded to the experimental hypotheses. Interobserver agreement (IOA) was reported to be within an acceptable range. Prior to the start of treatment, data was collected from each participant until stable baselines were achieved. Generalization probes for each target behaviour across stimuli, persons, and settings were also administered during baseline and follow-up phases. Well-described measures of efficiency were completed.

Visual analysis only of the data revealed that video modeling resulted in faster acquisition of target social skills for most participants (4/5 participants) and facilitated improved generalization as compared to the in-vivo modeling intervention. Time and cost efficiency measures revealed that video modeling was overall more efficient that in-vivo modeling. This study had many strengths, including the use of identical procedures between intervention conditions, the incorporation of generalization probes, and the blinding of the therapists and observers. Overall, this study provides suggestive evidence that the use of video-modeling may be an effective intervention to teach social behaviours to children with ASD.

Cihak et al. (2012) completed an alternating treatment study to examine the effects of using video modeling in conjunction with the Picture Exchange Communication System (PECS) to teach independent communication initiations to four three-year-old children. Only two participants had a diagnosis of ASD and thus, only their data will be reported in this review. Recruitment details and participant characteristics were described, but information regarding ASD diagnosis was not reported for one participant. Participants' preferred reinforcers were randomly assigned and counterbalanced across treatments. Each child participated in 3 baseline sessions during which they were given opportunities to exchange picture cards to request desired items. This was followed by between 11 and 17 intervention sessions, of which the order of conditions was randomized, using either PECS alone or video modeling in combination with PECS to teach requesting. The percentage of independent initiations demonstrated by each child was recorded, with acceptable IOA reported across participants and conditions. After participants reached acquisition criteria (100% independent initiation across three consecutive sessions), the preferred intervention condition was replicated using the stimuli of the less effective condition. Post-intervention, all instructors completed a social validity questionnaire, although limited details regarding this questionnaire were provided.

Visual inspection of the data only indicated that video modeling used in conjunction with PECS resulted in both faster and improved acquisition of independent requests as compared to PECS alone. Results from the social validity questionnaire indicated that all instructors believed that the combined PECS and video modeling condition produced the greatest treatment effect for all children. This study had a small and relatively homogenous sample. All participants were reported to be highly motivated by salient reinforcement and came from similar cultural and socioeconomic backgrounds, making generalization to all preschoolers with ASD problematic. Overall, this study provides slightly suggestive evidence for the efficacy of video modeling used in combination with PECS to teach requesting in preschoolers with ASD.

Using a single subject reversal design, **State & Kern (2012)** compared the effectiveness of video feedback and in-vivo self-monitoring interventions to improve the social interaction skills of a 14-year-old adolescent with Asperger syndrome. A detailed description of the recruitment process and the social communication skills of the participant was provided, although limited details regarding his diagnosis were reported. An initial baseline phase was completed, followed by alternating phases of video feedback and in-vivo self-monitoring interventions in which the participant engaged in interactive games at school with a peer or teacher. A follow up phase in which the participant completed the same social activities at home with his mother was included to assess generalization of the intervention effects across settings and social partners. Two independent observers coded for the occurrence of inappropriate and appropriate interactions and vocalizations, with IOA reported within acceptable limits. The participant also completed an adapted

version of a published measure of social validity for both intervention conditions.

Visual analysis only of the data revealed that both interventions resulted in a decrease in inappropriate interactions and noises with all social partners, although greater reductions were observed in the in-vivo self-monitoring condition. A decrease in inappropriate interactions was also observed during the generalization phase. High treatment acceptability ratings were obtained for both interventions, but in-vivo self-monitoring had an overall higher rating.

A major limitation of this study is that procedural differences were reported between interventions, including differences in the frequency of self-monitoring and feedback. It is possible that these differences may account for the improved outcomes obtained with the in-vivo intervention. Additionally, this study only examined intervention effects in one subject with ASD, which limits the ability to apply the study's results to the general population of children with autism. This provides somewhat suggestive evidence that in-vivo self-monitoring is more effective than video feedback to teach social skills to individuals with ASD.

Vanderborght et al. (2012) conducted a single subject, counterbalanced reversal study to investigate whether the presence of a social robot would improve the effectiveness of Social Stories intervention to teach social skills to four children with ASD (4 – 9 years). All participants were diagnosed according to gold standard measures. The inclusion criteria and characteristics of the participants were outlined in detail. Target social skills were measured on a 7-point scale based on the level of prompting required to elicit the appropriate social interaction. Individualized Social Stories were developed for each social skill according to published guidelines and were read to the participants either by a human therapist (eight sessions) or a robot (six sessions). After each session, all participants completed an experimental social task that required them to demonstrate the targeted skill. Baseline data was collected pre-intervention until data collection stability was reached. All baseline and intervention sessions were videotaped and scored by three trained graduate students, with acceptable IOA reported.

Visual analysis of the data revealed that the robotic intervention had a stronger effect on decreasing the level of prompting required to elicit the target social skill for all participants. However, appropriate non-parametric statistics revealed a statistically significant difference between interventions in only one of the total four participants. The researchers postulated that the results may have not been statistically significant as a conservative approach of statistical analysis was utilized. One major limitation of this study is that it did not measure the generalizability or maintenance of the intervention outcomes. Furthermore, additional limitations of the study include its small sample size and the lack of blinding reported. Overall, this study provides suggestive evidence that the administration of Social Stories via a robot may result in improved acquisition of social skills in children with ASD.

Wilson (2013) completed a single subject, alternating treatment design to compare the efficacy of video modeling to in-vivo modeling on increasing the social-communication skills of four children with ASD (3;9 – 5;4 years). Recruitment details, participant profiles, and inclusion criteria were well specified. Gold standard measures were utilized to confirm each participant's ASD diagnosis, language abilities, and imitation skills. Each participant completed a minimum of five baseline and two post-treatment follow-up observations, followed by between 5 and 15 in-vivo and video modeling sessions. The order of treatments was randomized, with at least one-hour allocated between each treatment. Intervention contexts were varied amongst the two conditions to minimize carry-over effects. The occurrence of target social behaviours and the participants' attentional states were recorded by blinded observers, of which only the former measure is of relevance to the current question. Following treatment, participating teachers and teaching assistants completed a published measure of acceptability and practicality for both interventions.

A non-parametric data overlap method revealed that in-vivo modeling was significantly more effective at improving the occurrence of target social skills in one participant, but no significant differences were found between treatment conditions for the remainder of the participants. Intervention effects were maintained two weeks post-treatment in half of the participants. Both interventions were found to exceed the minimum index of intervention acceptability.

A major strength of this study is that a high degree of treatment fidelity was reported, and samples of modeling scripts were included, allowing for easy replication of the interventions. However, stable baseline data was not achieved for one participant, which likely contributed to the lack of significant difference found between treatments for this participant. Another limitation of this study is related to the potential of carryover effects from one treatment to another due the study design, restricting the researcher's ability to draw conclusions about the differential effectiveness of the interventions.

Additionally, the use of the learned social skills to other contexts was not measured, limiting the study's external validity. Thus, this study provides slightly suggestive evidence that there is comparable effectiveness between video and in-vivo modeling interventions to teach social skills to children with ASD.

Malmberg et al. (2015) compared the effectiveness of video modeling and Social Stories to teach social skills using a multiple baseline design across four children (5-9 years) with ASD. Participants' baseline language skills and ASD diagnoses were confirmed with gold standard measures. Target social behaviours and stimuli were selected for each participant and counterbalanced across treatment conditions. Videos and Social Stories were individualized for each participant's target behaviour according to published guidelines. Prior to the introduction of intervention, each participant completed a 5-minute play session, in which baseline measures of target behaviour were collected. Between five and nine video modeling and Social Stories intervention sessions were administered to each participant, followed by 5-minute play sessions in which the occurrence of target behaviour was assessed and coded by two research assistants. Additionally, maintenance and generalization probes were administered post-intervention. Adequate IOA was reported.

Visual inspection of the data revealed that all participants successfully learned and maintained their target social behaviours during the video modeling condition, but not the Social Stories intervention. Furthermore, the observed intervention effects associated with the video modeling intervention generalized either to new settings or unfamiliar people for most participants. However, statistical analysis of the data was not performed. Another limitation of this study is that while randomization of social skills across conditions was employed, the social skills were not counterbalanced across treatment conditions. Overall, this study provides suggestive evidence that video modeling may be a more effective intervention than Social Stories to teach social behaviours to children with ASD

Ukle-Kurkcuoglu (2015) utilized an adapted alternating treatment design to compare the effectiveness and efficiency of least-to-most prompting and video modeling to teach pretend play skills to three children with ASD (5 – 6 years). Gold standard measures were utilized to confirm each participant's ASD diagnosis and IQ. Pretend play scenarios were chosen for each participant and randomly allocated to an intervention condition. Baseline probes were administered over three sessions. After stable baselines were collected, each participant completed between 6 and 11 least-to-most prompting and video modeling sessions, followed by a pretend play session in which the percentage of correct responses was recorded by the trainer and an independent observer. Both intervention conditions were randomly presented at different times of the day, with at least one hour in between treatment sessions. Once each participant displayed 100% correct performance over three consecutive sessions for each intervention condition, maintenance and generalization sessions were completed. Acceptable IOA was reported.

Using descriptive statistics only, the researchers concluded that both intervention conditions were effective to teach pretend play skills, although no differences were found between conditions. In both conditions, intervention gains generalized to other settings and trainers, and were maintained at one, two, and four weeks post-intervention, with no differences seen between interventions. This study had well-designed methods to ensure that the two intervention conditions were equal on multiple domains. Overall, this study provides suggestive evidence that there is comparable effectiveness between least-to-most prompting and video modeling interventions in teaching pretend play to children with ASD.

Plavnick & Vitale (2016) used a single subject, alternating treatment design to compare the effectiveness of video-based training with in-vivo training on the acquisition and mastery of requesting behaviour in four pre-school children with ASD (2;11 – 3;6 years). Participants were recruited from a local school district and were included in the study based on the presence of a previous diagnosis of ASD and an expressive language impairment, confirmed using a well-recognized assessment instruments.

All participants completed an initial baseline in which participants received "instruction-as-usual", followed by alternating video-based and in-vivo interventions to elicit requesting for six high-preference stimuli, administered five times a week by a trained therapist. Appropriate matching and randomization of items across intervention conditions was reported. All therapists completed a published measure of social validity to assess the acceptability and feasibility of the video modeling intervention. Observers recorded prompted and independent requests, incorrect responses, with acceptable IOA ranges reported.

Visual inspection of the data revealed that three of the four participants acquired and mastered more requesting behaviour in the video training condition. However, no statistical analysis of the data was

completed. Mean ratings on the social validity measure suggested that video modeling was considered to be an acceptable procedure to teach requesting and could be implemented independently within the constraints and demands associated with therapists' jobs. However, there were several differences between the two intervention conditions, including differences between the length of time and schedule of reinforcement. Additionally, generalization of treatment gains was not assessed, limiting the external validity of the results. Considering the strengths and limitations, this study provides suggestive evidence regarding the effectiveness of video modeling on teaching children with ASD to request.

Randomized Controlled Trials:

Srinivasan, Eigsta, Gifford, & Bhat (2016) compared the effects of rhythm, robotic and Applied Behavioural Analysis (ABA)-based interventions on the spontaneous verbal communication skills of 36 children with ASD (5-12 years; m=7.63). Recruitment details and inclusion criteria were well-specified and ASD diagnosis was confirmed using gold standard diagnostic measures. Participants were matched on age, level of functioning, and amount of prior services, and then randomly allocated to an intervention group (n=12). The rhythm and robotic interventions utilized whole-body imitation games, with the rhythm and robotic therapy being administered by either a human trainer or a robot trainer. In contrast, the comparison ABA intervention included sedentary activities typical of those included in school-based therapy sessions. Treatment contact time was kept similar across groups, and was conducted over ten weeks, with the children receiving two trainer-led sessions and two parent-led sessions per week.

A modified version of a standardized test of joint attention (JTAT) (Bean & Eigsti, 2012) was administered in the first and last weeks of the study to assess the children's responsive and non-verbal communication skills. However, three children were reported to not cooperate during JTAT administration, resulting in data being reported for only 11 children per group. Additionally, the children's responses to social bids and their total duration spent spontaneously or responsively verbalizing to themselves, their social partners, and the robot were coded by a single observer at three time points (early, mid, and late sessions). Intra- and inter-rater reliability was reported to be within acceptable range. Social bids were not administered to two children within the rhythm group due to lack of cooperation during the given session.

Using appropriate tests of difference, no significant differences were found between the intervention groups in JTAT performance, although the rhythm and ABA groups but not the robotic group, increased their total scores post-intervention. Children in the robotic group were found to engage the most in self-directed vocalization, while the children in the ABA and rhythm groups exhibited greater spontaneous social verbalization. Within the robotic and rhythm groups, the children showed an overall increase in social verbalization from early to late sessions, while no training-related improvements in social verbalization was observed in the ABA group.

One limitation is that some children in the study did not cooperate with the study administration, resulting in the researchers not having complete data from entire sample. Furthermore, a single coder was reported to have completed the data analysis with no mention of blinding, which could result in the data being subject to bias. This study also did not perform follow-up testing to assess the carry- over and generalizability of the training. Overall, this study provides strongly suggestive evidence against the effectiveness of robotic interventions to increase social verbalization in children with ASD.

Discussion

Overall, findings provided suggestive evidence that technology-based interventions are an effective therapy delivery method to teach social-communication skills in children with ASD. In total, nine articles were selected for review, of which four (Charlop-Christy et al., 2000, Cihak et al., 2012, Malmberg et al., 2015, Plavnick & Vitale, 2016) reported that the technology-based interventions resulted in greater treatment outcomes as compared to the non-technology interventions. However, Ukle-Kurkcuoglu (2015), Wilson (2013), Vanderborght et al (2012), and Srinivasan et al. (2016) reported comparable outcomes between treatments, while State & Kern (2012) found that in-vivo modeling intervention was superior to video-modeling. The majority of the reviewed studies (Ukle-Kurkcuoglu, 2015, Plavnick & Vitale, 2016, Malmberg et al., 2015, State & Kern, 2012, Cihak et al., 2012, Carlop-Christy et al., 2012**)** were limited by the lack of statistical analyses for the outcome measures reported on, which makes it difficult to determine whether the results of these studies are significant.

Eight of the papers (Charlop-Christy et al., 2000, Cihak et al., 2012, Malmberg et al., 2015, Plavnick & Vitale, 2016, State & Kern, 2012, Ukle-Kurkcuoglu, 2015, Vanderborght et al., 2012, and Wilson, 2013) utilized single-subject research designs (SSRDs), including multiple baselines across participants, reversal, and alternating treatment designs. In SSRDs, each

participant acts as their own control, allowing for the systemic manipulation of the variables. This design is particularly useful to evaluate intervention effectiveness, especially when it is difficult to obtain a homogenous group of participants, as it is with ASD. Srinivasan et al. (2016) utilized a randomized clinical trial (RCT) design. RCTs randomly assign participants to conditions to measure the dependent variable under controlled conditions, which better allows for cause-and-effect relationships to be determined. Overall, the choice of designs utilized by the included studies were appropriate and provided a high level of evidence as to whether the various interventions were effective.

A limitation across the majority of the studies was the use of small sample sizes (<10 participants). Although this is a limitation inherent to SSRDs, small sample sizes can impact the external validity and ability to generalize the intervention outcomes to the greater population of children with ASD. However, it should be noted that these studies provided detailed descriptions of the participant characteristics. This information can be useful when clinicians are determining the suitability of an intervention for a child their similarity to the study's participants. Furthermore, the studies included children with ASD that encompassed a wide range of functioning, further enhancing the ability of the study findings to be generalized to the larger ASD population.

Many of the studies (Charlop-Christy et al. 2012, Cihak et al. 2012, State & Kern, 2012, Ukle-Kurkcuoglu, 2015, Malmberg et al., 2015) included measures of target skill maintenance and generalization post-intervention. These measures are especially important to be included in research evaluating interventions for individuals with ASD as it has been noted that generalizability is particularly difficult for this population (Silton, 2003). Furthermore, the overall purpose of social skills interventions for children with ASD is to improve their overall functioning when they encounter social situations. Thus, it is essential that effective interventions demonstrate that these acquired skills generalize to untrained social contexts. Results from all studies that incorporated maintenance and generalization outcome measures revealed that treatment gains from the technology-based interventions were maintained post-intervention and generalized to new environments and social partners. These findings strengthen the practicability and usefulness of technology-based social skills interventions.

Only the studies performed by Charlop-Christy et al. (2000) and Wilson (2013) reported using blinding procedures, resulting in a high possibility of potential bias in many of the studies. While blinding of the participants and clinicians was likely not possible due to the nature of the interventions and study designs, it would have been quite feasible to blind the data collectors and analysts to ensure unbiased outcomes. Of particular concern is that the study by Srinivasan et al. (2016) did not report any form of blinding, despite the fact that it is an important component that should be incorporated in randomized controlled study designs. Overall, the lack of blinding utilized by most of the studies limits the strength of the reported findings.

Clinical Implications

The rising incidence of children diagnosed with ASD (Centre for Disease Control and Prevention, 2014), combined with the fact that different technologies are becoming more readily available has made technology-based interventions particularly promising to teach social skills to individuals with autism. Overall, the articles included in this review are suggestive that technology-based interventions may effectively teach social skills to children with ASD. However, due to the heterogeneous nature of this population, clinicians should always use their clinical judgment before applying any intervention to a child with ASD. It is essential that each child's individual characteristics and unique needs be considered to determine whether a technology-based intervention would be effective to teach that child various social communication skills.

Several different technologies are being introduced to teach a broad range of social skills to children with ASD. However, the studies that met the inclusion criteria of this review included only two types of technology - video modeling and robotic interventions. It is likely that the studies included in this review do not capture the range of different technology-based social skills interventions readily available and used with children with ASD, including tablet and computer-based applications. Thus, additional research is required to compare the effectiveness of a greater variety of technology-based interventions to that of more traditional interventions. Furthermore, future research should also address the previously discussed limitations within the review, including the use of statistical analyses in addition to visual analysis of the data, increasing sample sizes to better represent the general ASD population, and blinding all raters and therapists involved in the study to avoid potential bias.

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