Assistive Technology for Promoting Adaptive Skills of Children with Autism Spectrum Disorders: A Literature Overview

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Abstract

Individuals with autism spectrum disorders are commonly described with emotional, intellectual, communicative and social impairments. They are frequently isolated and passive with few opportunities of positive and constructive interaction with the outside world. Accordingly, they may exhibit withdrawal, stereotypic and challenge behaviors. The aforementioned conditions might seriously hamper their social image and status, with negative consequences on their quality of life. One way to overcome this issue is the use of assistive technology aimed at promoting adaptive skills, self-determination and active role towards the environment by participants involved. The first goal of this paper is to provide an overview of the empirical evidences available in the last fifteen years (i.e. 2000-2015, that is the time period with the wide production of such studies). Overall, 33 studies were selected, involving 184 participants. The second objective of the overview is to emphasize strengths and weakness of such evidences. Finally, clinical, psychological and rehabilitative implications of the findings were discussed and practical guidelines within this topic area as future research perspectives were outlined.

Keywords

Assistive technology, Autism spectrum disorders, Adaptive skills, Quality of life, Indices of happiness, Social validation

Introduction

Assistive Technology (AT) defines and includes any device, equipment or piece that promotes new skills, increases existing (i.e. adaptive) behaviors, or reduces the negative consequences of disabilities on daily functioning [1,2]. The adopted technology may be sophisticated (i.e. high tech) or simply (i.e. low tech). For instance, a child may be exposed to a complex computer-based program aimed at enhancing his/her request and choice opportunities or could exchange pictures or cards for communicative purposes [3,4]. Irrespective of its complexity, AT is focused on the improvement of independence and self-determination of participants involved, with beneficial effects on their quality of life [5,6]. That is, based upon learning principles (i.e. causal association between a behavioral response and environmental consequences), AT promotes the positive practice of such principles [3].

Children with autism spectrum disorders (ASD) may be considered as privileged recipients of an AT-based program, due to their difficulties emerging from their pathologies and their learning incapacities associated with their symptoms and behavioral features [7,8]. For example, one may envisage an alternative and augmentative communication (AAC)-based intervention through a speech-generating device (SGD) or self-management of instruction cues for promoting functional activities and decreasing stereotypic behaviors [9,10]. Additionally, AT may be viewed as useful for temperate many of the common obstacles arising from developmental disabilities (DD), motor impairments and challenge behaviors such as aggression or self-injury [11,12].

The first objective of this paper is to provide an overview of the empirical evidences available in the last fifteen years (i.e. 2000-2015, as time period with a large production of such evidences) involving AT-based programs for education, research and practice towards individuals with ASD. The second goal of the paper is to emphasize strengths and weakness of the reviewed studies. Finally, the paper guides practitioners and researchers pointing out the effectiveness of AT for improving the quality of life of children with ASD.

Method

A computerized search was carried out within electronic database such as Scopus, Medline, Psych Info, and ERIC using the following keywords: (a) autism spectrum disorders, (b) intellectual disabilities, (c) developmental disabilities, (d) assistive technology, (e) communication impairments, (f) adaptive behaviors, (g) stereotypic behaviour, (h) aggression, (i) quality of life, (j) indices of happiness, and (k) self-determination. A manual search was additionally performed as supplement and research completion. Including criteria concerned: (a) empirical studies (i.e. research articles), (b) at least one participant who was between 3 and 19 years old (i.e. child or adolescent), (c) the English language of the article, and (d) an AT-based intervention program. Excluding criteria were: (a) systematic...
review paper, book chapter, conference papers and/or meta-analysis, (b) assessing studies without intervention protocol, (c) only adults as participants involved, and (d) participants with Rett syndrome, as their inclusion would exceed the goal of this paper. Accordingly, thirty-three studies were included in the review, involving 184 participants. Specifically, three main domains were considered, namely: (a) communication skills, (b) social and emotional skills, and (c) adaptive and living skills. For each domain, the reviewed studies were examined in terms of the number of participants involved and their ages, AT devices used and/or procedures adopted targeted behaviors and outcomes. A synoptic tab summarizing the included studies will be available. Regardless of the number of the studies retained for each domain, two illustrative evidences will be discussed for every area, for practical reasons.

Overview

AT for communication purposes

Individuals with ASD may exhibit a large range of communication impairments [13,14]. For example, they may present a significant poor speech repertoire, repetitive language (e.g. people with Asperger syndrome), gaze avoidance, withdrawal, disorientation, and echolalia. These conditions may widely interfere with daily life, preventing those individuals towards real forms of integration [15,16]. In fact, deficits in communication may impede their inclusion within educational and community settings, with deleterious consequences for their quality of life [17]. Consequently, AT-based programs are centred to improve their communicative potentials as basic forms of AAC [18]. In fact, AAC-aided systems rely either on high technology-devices such as computers, tablets, I-pad, SGD, or on low-technology strategies such as PECS [18,19]. Since the selected technological solution may significantly influence the person’s success, it should be always rigorously individualized, as to ensure the participant with a solution may significantly influence the person’s success, it should be always rigorously individualized, as to ensure the participant with a profitable way to constructively communicate with the outside world [20,21]. Overall, 11 studies were retained within this section, with 126 participants involved (Table 1).

For instance, Copple, Koul, Banda and Frye [22] proposed to three preschool children with autism spectrum disorders a SGD following a video-modelling intervention and a generalization phase to request a preferred object to social partners. The study was carried out according to a multiple baseline design across participants.

During the intervention phase all participants were provided with a video showing two adults who requested a preferred item using a SGD. Results emphasized that all participants learned to use the SGD and successfully generalized their learning capacities across partners and objects. The study pointed out that the AT-based program was helpful in improving communication skills of participants involved.

Sigafoos, O’Reilly, Seely-York and Edrisinha [31] taught to two non verbal adolescents diagnosed with ASD, 16 and 12 years old respectively, to use a VOCA to request access to preferred items. A least-to-most prompting procedure was assessed for enabling participants to locate their AT-device. The study was carried out through a delayed multiple-baseline across subjects design. Results showed that both students learned to locate their VOCA once the procedure was implemented. Thus, both participants correctly used their AT-device for requesting preferred objects. Authors concluded that teaching VOCA location skills may be helpful and may constitute an essential element in AAC interventions for participants with ASD.

AT for Social Skills

According to diagnostic criteria [33], ASD include deficit in social skills (e.g. lack of eye contact, poor peers relationships, low joint attention, failure in social and emotional reciprocity). Bauminger and Kasari [25] compared a group of 22 high functioning ASD children with a group of 19 typically developed children to assess their capacity of establish friendship and be aware of loneliness. Data showed that within the experimental group (i.e. children with ASD) levels of friendship were significantly lower compared to those of the control group, in terms of stability and security. Furthermore, reduced feelings of lonely were observed in the experimental group. Results suggested that social deficits and emotional difficulties might cause isolation and social anxiety, which are dominant among ASD individuals [34,35].

Accordingly with the above, AT-based interventions are aimed at improving social relationships and functioning within ASD population [36]. That is, AT programs are essentially computer-based instructions (CBI) which may be at least partially faded and/or eliminated, once social skills have been learned [37,38]. For instance, Hopkins et al. [39] exposed 49 ASD children to a computer-based program finalized to promote eye contact, acquire the ability of discriminating and recognizing facial emotions and expressions.

### Table 1: Synoptic representation of the reviewed studies on communication.

<table>
<thead>
<tr>
<th>Studies</th>
<th>Participants</th>
<th>Range Age</th>
<th>AT</th>
<th>Targeted Behaviors</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copple et al. [22]</td>
<td>3</td>
<td>3.5-5</td>
<td>SGD</td>
<td>Request and Choice</td>
<td>Three positive</td>
</tr>
<tr>
<td>Couper et al. [23]</td>
<td>9</td>
<td>4-9</td>
<td>SGD</td>
<td>Manual Signs</td>
<td>Five positive</td>
</tr>
<tr>
<td>Kasari et al. [24]</td>
<td>61</td>
<td>5-8</td>
<td>SGD</td>
<td>Communicative Skills</td>
<td>Sixty one positive</td>
</tr>
<tr>
<td>Flores et al. [25]</td>
<td>5</td>
<td>6-10</td>
<td>I-Pad and Cards</td>
<td>Communicative Skills</td>
<td>Two negative</td>
</tr>
<tr>
<td>Ganz et al. [26]</td>
<td>2</td>
<td>4-5</td>
<td>Verbal modelling and PECS</td>
<td>Verbal Requests</td>
<td>Two negative</td>
</tr>
<tr>
<td>Yoder &amp; Liberman [27]</td>
<td>36</td>
<td>1.5-5</td>
<td>PECS and Pre-linguistic milieu teaching</td>
<td>Coordinated Attention</td>
<td>Thirty six positive</td>
</tr>
<tr>
<td>Franco et al. [28]</td>
<td>1</td>
<td>7</td>
<td>SGD</td>
<td>Vocal Utterances</td>
<td>One positive</td>
</tr>
<tr>
<td>Ganz et al. [29]</td>
<td>3</td>
<td>6-9</td>
<td>PECS</td>
<td>Requests Words</td>
<td>Three positive</td>
</tr>
<tr>
<td>Son et al. [30]</td>
<td>3</td>
<td>4-5</td>
<td>PECS and VOCA</td>
<td>Requesting Behaviour</td>
<td>Three positive</td>
</tr>
<tr>
<td>Sigafoos et al. [31]</td>
<td>2</td>
<td>12-16</td>
<td>SGD</td>
<td>Requests Behaviour</td>
<td>One negative</td>
</tr>
<tr>
<td>Sigafoos et al. [32]</td>
<td>1</td>
<td>12</td>
<td>SGD</td>
<td>Request Objects</td>
<td>One positive</td>
</tr>
</tbody>
</table>

### Table 2: Synoptic representation of the reviewed studies on social skills.

<table>
<thead>
<tr>
<th>Studies</th>
<th>Participants</th>
<th>Range Age</th>
<th>AT</th>
<th>Targeted Behaviors</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ganz et al. [40]</td>
<td>1</td>
<td>5</td>
<td>Tablet</td>
<td>Photos Identification</td>
<td>One positive</td>
</tr>
<tr>
<td>Axe and Evans [41]</td>
<td>3</td>
<td>5</td>
<td>Video Modelling</td>
<td>Facial Recognition</td>
<td>One negative</td>
</tr>
<tr>
<td>Trottier et al. [42]</td>
<td>2</td>
<td>11</td>
<td>SGD</td>
<td>Communicative acts</td>
<td>Two positive</td>
</tr>
<tr>
<td>Chartop et al. [43]</td>
<td>3</td>
<td>7-11</td>
<td>Video Modelling</td>
<td>Social Verbalizations</td>
<td>Three positive</td>
</tr>
<tr>
<td>Sancho et al. [44]</td>
<td>2</td>
<td>5</td>
<td>Video Modelling</td>
<td>Verbalizations</td>
<td>One negative</td>
</tr>
<tr>
<td>Tetreault and Lerman [45]</td>
<td>3</td>
<td>5-8</td>
<td>Video Modelling</td>
<td>Eye Contact</td>
<td>One negative</td>
</tr>
<tr>
<td>Wichnick et al. [46]</td>
<td>3</td>
<td>5-7</td>
<td>VOCA</td>
<td>Response to peer</td>
<td>Three positive</td>
</tr>
<tr>
<td>Lacava et al. [47]</td>
<td>8</td>
<td>8-11</td>
<td>CBI</td>
<td>Emotions Recognition</td>
<td>Eight positive</td>
</tr>
<tr>
<td>MacDuff et al. [48]</td>
<td>3</td>
<td>3-5</td>
<td>Audio Script</td>
<td>Joint Attention</td>
<td>Three positive</td>
</tr>
<tr>
<td>Maione and Mirenda [49]</td>
<td>1</td>
<td>5</td>
<td>Video Modelling with feedback</td>
<td>Social Initiations</td>
<td>One positive</td>
</tr>
<tr>
<td>Shabani et al. [50]</td>
<td>3</td>
<td>6-7</td>
<td>Vibrating Paper</td>
<td>Verbal Initiations</td>
<td>Three positive</td>
</tr>
</tbody>
</table>
Subsequently the implementation of the intervention, the children significantly improved their performances by increasing their capacities of identifying facial expressions and emotions. Moreover, they all augmented their social skills with peers. Overall, 11 studies were selected within section, with 32 participants involved (Table 2).

Ganz, Hong, Goodwyn, Kite and Gilliland [40] exposed a pre-school aged boy with autism to a tablet-based program aimed at promoting receptive identification of photos through an AAC system with voice output. The tablet prompted the participant and provided a vocal feedback for the response correctness during intervention phases. A multiple baseline single-case experimental design across vocabulary words was implemented. Results showed a mild improvement for two of three vocabulary words selected.

Shabani et al. [50] carried out a study with three boys diagnosed with autism who were exposed to a vibrating paper-based program for enhancing their social initiations with other children during a play and for acquiring responding capacities to social interactions with peers. The vibrating paper was activated by a therapist once a social initiation and/or a social interaction were observed. Participants were previously taught to use such technology for their constructive engagement in social initiations/interactions. A reversal design was implemented. Results emphasized that all participants significantly increased their performance during intervention phases compared to baselines. Moreover, for all of them the use of the technology seemed to be purposeful.

AT for adaptive and daily skills

A third relevant issue for ASD individuals is represented by adaptive and daily skills. That is, on-task behaviour and/or constructive engagement for dressing, time and/or money management, recreational skills are essential for the independent functioning of a person within daily settings (e.g. home, school, community) [51]. Furthermore, self-determination might be increased and isolation reduced by acquiring adaptive behaviours. Children with ASD often fail to learn the adaptive skills needed for an independent life and consequently rely on caregivers [52]. Overall, 11 studies were selected within this section with 26 participants involved (Table 3).

For example, Lee et al. [54] implemented a comparison between an I-Pad and an intervention delivered by a therapist for promoting the on-task behaviour and reducing the challenge behaviour through an alternating treatments design for two children with ASD. Results emphasized that the I-Pad was effective and useful if compared to the intervention mediated by the therapist. In fact, its use was associated with increased on-task behaviour and a reduced challenge behaviour for both participants involved.

Stasolla, Damiani and Caffo [57] exposed two high functioning boys diagnosed with ASD to a comparison between a computer-based intervention and a traditional task (i.e. based upon paper and pencil), for promoting constructive engagement and decreasing stereotypic behaviour. The study was carried out through a multi-elements baseline design. Results pointed out that both participants increased their constructive engagement and reduced stereotypic behaviours during intervention phases. Moreover, both preferred the computer-based intervention instead of the traditional program.

Table 3: Synopsis representation of the reviewed studies for adaptive and daily skills.

<table>
<thead>
<tr>
<th>Studies</th>
<th>Participants</th>
<th>Range Age</th>
<th>AT</th>
<th>Targeted Behaviors</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burckley et al.</td>
<td>1</td>
<td>19</td>
<td>I - Pad</td>
<td>Independence</td>
<td>One positive</td>
</tr>
<tr>
<td>Lee et al. [54]</td>
<td>2</td>
<td>6-7</td>
<td>I - Pad</td>
<td>On - task and challenge behaviours</td>
<td>Two positive</td>
</tr>
<tr>
<td>Vandermeer et al.</td>
<td>3</td>
<td>4</td>
<td>I - Pad</td>
<td>On - task behaviour</td>
<td>Two negative</td>
</tr>
<tr>
<td>Stasolla et al.</td>
<td>3</td>
<td>8.4-10.2</td>
<td>Microswitches</td>
<td>Adaptive and challenge behaviours</td>
<td>Three positive</td>
</tr>
<tr>
<td>Stasolla et al.</td>
<td>2</td>
<td>7-8</td>
<td>Laptop</td>
<td>Constructive engagement and stereotypic behaviour</td>
<td>Two positive</td>
</tr>
<tr>
<td>Bereznak et al.</td>
<td>3</td>
<td>15-18</td>
<td>I - Phone</td>
<td>Task - Analysis correctness</td>
<td>Three positive</td>
</tr>
<tr>
<td>Rosenberg et al.</td>
<td>3</td>
<td>3-5</td>
<td>Video - Modelling</td>
<td>Task - Analysis correctness</td>
<td>Three positive</td>
</tr>
<tr>
<td>Van Laarhoven et al.</td>
<td>2</td>
<td>13-14</td>
<td>Picture and Video Prompts</td>
<td>Task - Analysis correctness</td>
<td>Two positive</td>
</tr>
<tr>
<td>Ayres et al. [61]</td>
<td>3</td>
<td>7-9</td>
<td>CBI</td>
<td>Task - Analysis correctness</td>
<td>Three positive</td>
</tr>
<tr>
<td>Hutcherson et al.</td>
<td>1</td>
<td>16</td>
<td>CBI</td>
<td>Correct responses</td>
<td>One positive</td>
</tr>
<tr>
<td>Shipley - Benamou et al.</td>
<td>3</td>
<td>5-6</td>
<td>Video - Modelling</td>
<td>Task - Analysis correctness</td>
<td>Three positive</td>
</tr>
</tbody>
</table>

Discussion

The reviewed studies summarized the use of AT devices and programs for improving communication, social and adaptive skills of children with ASD. The outcomes were largely positive, although some failures occurred (i.e. 7.6%). Thus, AT-based interventions were effective and successful by increasing self-determination and independence of participants involved in daily contexts, with positive consequences on their quality of life. Thus, by promoting their active role, AT-based interventions significantly facilitated the inclusion of children with ASD with beneficial effects on their social image, desirability and status. Data of this overview were supported by previous findings [64,65], allowing to put forward the following considerations.

With regard to the first group (i.e., communication skills), the literature available outlined that AT-based interventions were useful as it increased the opportunity of requesting preferred items, ignoring non-preferred and/or neutral activities, beginning conversational interactions. Despite the aforementioned outcomes, it seems that AT has been focused, at least up today, to what may be considered the beginning of communication abilities. Assessing the complexity of AT and its potential, the extension of such interventions should be addressed at more structured, articulated communication possibilities, as to enable participants with ASD with more sophisticated communications. For example, one may envisage technological solutions ensuring individuals with ASD to the literacy process, and/or to independently access to phone calls opportunities [66,67]. Else, one may argue that next to the familiar partners considered among the reviewed studies, it is undoubtedly necessary to generalize the findings to unfamiliar partners, considering natural settings, added to home, educational and medical contexts [68]. Moreover, it may be interesting to deal with communities members’ perceptions through social validation assessments [69,70]. The latter extension may represent an important clinical issue for future research within this topic area [71].

With regard to the second issue (i.e. social skills), one may argue that AT-based treatments were successfully applied to a considerable range of social/emotional skills, including recognizing emotions and/or facial expressions, promoting joint attention and eye contact. Although the examined areas within this topic deal with a relevant number of problems exhibited by children with ASD, the existing literature within this specific framework is still limited. For instance, one may envisage the use of AT for extending the knowledge and the identification/recognition of other social emotions such as shame, proud and/or towards the empathy process [72]. Additionally, one may argue that the use of AT devices and/or procedures should be extended as well. That is, high-technology-based solutions such as smart-phones, I-Pod, virtual reality and/or robots might be further investigated [73].

With regard to the third category (i.e. adaptive/daily skills), the AT-based interventions emphasized the enhancement of relevant abilities, including complete functional activities and decreasing ritual, stereotypic and/or challenge behaviours accordingly [74]. Its application, however, appears still limited with respect to the adopted solutions, although broadly applicable in daily life domains. Thus,
the AT used should be further extended to new emerging portable options, as to continuously transfer its use from an environment to the other [75].

Irrespective of the domain where it has been used (i.e. for communicative, social and/or adaptive goals), a relevant clinical concern is to determine whether and when AT is requested and/or required. Furthermore, it is recommended to select and consequently adopt the most effective and/or efficient AT solution, considering the following issues: (a) participant’s characteristics, (b) environment availability, and (c) human and economical resources [76,77]. According to the aforementioned issues, it can be argued that one should carefully examine the following variables: (a) participant’s motor impairments, (b) participant’s alertness/vigilance, (c) participant’s impulsiveness, (d) participant’s skills, (e) motivational components, (f) environment’s demands, and/or (g) parents and care givers expectations [78]. Additionally, the participant’s preferences seem to play a crucial role for the decision-making process concerning the most suitable AT solution that should be selected [79]. Moreover, preferences of the families and/or caregivers should be analyzed, as to provide the best individualized AT-based option for each participant exposed to such interventions [80].

Conclusion

The general conclusion emerging from this literature overview presents AT as a great value resource and a relevant way for ensuring children with ASD and/or developmental disabilities to positively and constructively interacting with the surround and outside world, playing an active role and enhancing self-determination. The reviewed studies provide a general picture added to some illustrative examples for readers dealing with those individuals. That is, professionals interested with children exhibiting ASD may find some significant and useful support and consequently reduce their burden. However, caution is undoubtedly needed. In fact, beside the small number of studies/participants retained (i.e., thirty-three studies including 184 participants), one should also examine the suitability of the adopted AT solutions within a plausible rehabilitative program. For example, one may argue that children with ASD frequently need systematic instructions and intensive treatments rather than the mere provision of an AT solution. In light of above, new research perspectives in this area should deal with the following topics: (a) new and further extension and/or updating of AT options to new participants with ASD, (b) envisage more generalization, maintenance, follow-up phases in order to assess the consolidation of learning by participants involved, (c) carry out preference check phases, (d) conduct social validation procedure involving students, teachers, parents and caregivers as external raters, and (e) eventually integrating alternating and systematically different AT strategies within a unique experimental research design [81,82].

References


