An Analytic Tool for Assessing Learning in Children with Autism

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Abstract. One approach for teaching subjects with autism is Applied Behavior Analysis (ABA). ABA intervention aims to model human behavior by observing, analyzing and modifying antecedents and/or consequences of a target behavior in the environment. To achieve this, many data are recorded during each trial, such as subject response (correct/incorrect, level of prompt, inappropriate behavior, etc.). In this paper we present a web application that aggregates and visualizes data collected during technology-enhanced educational sessions, in order to monitor learning in children with autism. In a previous study we developed a free open source web application called ABCD SW, to support educators in administering ABA programs. In this study we present a learning analytic tool that retrieves, aggregates and shows -- in graphical and table form -- data gathered by ABCD SW. This software offers accurate real-time monitoring of children's learning, allowing teachers to analyze the collected data more rapidly, and to accurately tune and personalize the intervention for each child.

Keywords: Learning Analytic tool, Data Analysis, web application, Autism, ABA.

1 Introduction

Autism Spectrum Disorder (ASD) is a type of Pervasive Developmental Disorder that affects individuals with varying degrees of impairment. In general, it concerns three areas of disability: (a) communication, (b) socialization, (c) repetitive and stereotyped patterns of behavior, play and interests [1]. Early and intensive educational approaches are needed to minimize the disability's impact and better exploit the subject's abilities. One method specifically applied to teaching subjects with autism is Applied Behavior Analysis (ABA), a scientific approach that has proved to be very effective in this field ([2], [3]). ABA models human behavior by observing, analyzing and modifying antecedent and/or consequence behaviors, focusing on objectivity and systematic measures. The main criterion is to observe the environment that provides the stimuli to which a person responds, and the environment in past experiences that caused the same stimulus-response association [4]. Children are more likely to repeat

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or maintain behaviors and responses that are rewarded or reinforced by giving them something they like very much. The reinforcement is progressively reduced so that the child can learn without constant rewards.

Usually, software and technology can be used in a worthwhile way by autistic persons, keeping in mind any potential disturbance caused by colors, lights, animations, automatic behaviors implemented on the screen, etc. Nearly all children are attracted to computers, and when interacting with them feel free from expectations and social behavioral rules. Several studies have shown the effectiveness of computer-based training for teaching a variety of skills to children with autism ([5], [6], [7]).

We have developed a free open source web application (ABCD software) to help educators administer basic ABA programs facilitating early teaching of children with autism [8]. This software allows the child to become familiar with categories -- such as food, animals, colors -- and their articles -- such as apple, dog, and yellow (discriminative training). Usually, the ABA educators propose certain exercises of increasing levels of difficulty to a child, using cardboard pictures or real objects. Decreasing the time needed for the trial set-up, the ABCD SW automates the execution of three basic exercises: 1. matching programs, with combinations of images and words; 2. receptive programs, with the recognition of an article among others; 3. expressive programs, for labeling an article with verbal expression or -- for non-verbal children -- with text labels. The didactic software allows the educator to just press a key to quickly insert subjective data such as the type and level of prompt provided to the child, crucial for monitoring and evaluating learning progress. All data produced during the session -- article, category, execution time, success/error, prompt, etc., are automatically recorded and stored by the software.

In order to efficiently analyze the enormous amount of data collected by this software, we developed a learning analytic tool, described in this paper. This tool automatically extracts, aggregates and visualizes the children's performance data related to the ABA programs performed with the ABCD SW. The learning process is more effective when educators perform systematic data collection and analysis [9]. The analytic tool provides the teachers with easy real-time monitoring of learning progress, extracting data to assess a variety of skills and behaviors, and thus enabling the continuous evaluation and personalized tuning of the didactic intervention.

In the following, we first introduce basic ABA principles with special focus on data collection, as well as other studies in the field. Next, we describe the proposed learning analytic tool.

2 Data in ABA Intervention

For simplicity's sake, in the following the term "tutor" will refer to all members of the ABA team, with various levels of experience, including (special needs) teachers, educators, communication assistants, parents and caregivers.

ABA intervention requires collecting data about learning activities (e.g., subject's behaviors and skills acquired) in order to evaluate the effectiveness of intervention procedures. The aim of ABA methodology is to improve the abilities

(communication, socialization, etc.) of a subject and increase his/her frequency of appropriate behaviors, while discouraging and extinguishing problem behaviors. For this, different types of data must be recorded, such as correct/incorrect responses and occurrence of inappropriate behaviors (problem behaviors/self stimulation/no collaboration), to analyze the subject's progress and better refine the intervention. According to several studies, early intervention in children affected by autism disorder is more effective for learning and developing social abilities ([10], [11], [12]).

The creator of ABA intervention, Loovas [2] recommended recording data for each trial proposed to a child. Today, some studies suggest considering accurate data collection since recording large amounts of data can interfere with performing the ABA session itself, and thus with learning, especially if data are recorded manually. In this context, professionals have provided recommendations for building data collection related to the child's daily activities, using efficient data collection techniques and when possible, selecting procedures that can be executed during other tasks [13]. In order to understand the type of data to collect, a more detailed look at how ABA intervention works is provided in the following.

The ABA approach to autism utilizes several strategies and tools. Usually it relies on Augmentative and Alternative Communication (AAC) and Discrete Trial Training (DTT). DTT can help autistic children who often do not learn spontaneously as typically developing children do naturally, through imitation [14]. According to [15], DTT learning procedures improve attention, motivation, discrimination between relevant stimuli (stimulus control), generalization, cause-effect relationships, observational learning and communication. Each discrete trial has five components [16]:

1. Antecedent: a discriminative stimulus, for soliciting the behavior (a request by the tutor or an element in the environment that is highlighted)
2. Prompt: a cue or suggestion provided by the tutor to facilitate the child's answers
3. Response of the subject
4. Consequence for a correct response (reinforcement) or for an incorrect response
5. Inter-trial interval: a brief pause between consecutive trials when the tutor records the trial data.

The skill to be learned is broken down into small units for easy learning; there is a systematic repetition of each small unit (trial) according to the subject's needs. The ABA errorless principle requires that during the learning phase, each response of the child can be prompted to prevent the subject from providing an incorrect answer, since it is very difficult to correct the error later. The prompt is gradually removed ("prompt fading") when the child becomes more familiar with the trial.

In the ABA method, performance data related to each trial are: (i) correct, (ii) incorrect, (iii) non-response, (iv) correct but prompted, (v) incorrect but prompted responses [17]. Then, when the educational aims increase, a simpler correct/incorrect data collection scheme can be used to measure the child's answers, focusing on the amount of prompt used by the tutors in each trial.

Data collection is crucial for analyzing whether and how educational programs for subjects with autism are evolving. ABA programs take into account considerable data regarding the child's progress, such as the frequency of challenging behavior and the

percentage of correct behaviors. Recording the entire educational process is an important aspect of an educational program. Data collection helps measure the effects of the intervention, thus allowing the tutors to better refine it. Every change in the learning process can be observed from stored data. Monitoring a child's learning progress through the analysis of collected data also allows replacing interventions that do not seem to be beneficial for a child. In other words, data collection allows making more effective personalized changes to the program, based on children's abilities and real evidence.
According to [18] two types of behavior sampling can be identified:

- Event sampling: the count of the frequency or occurrence of a defined behavior in a period of time. This sampling indicates how many times the behavior occurs in a period of time (minutes, hours, days, months, etc.). Event sampling is useful in counting discrete behaviors with clear beginnings and endings.
- Time sampling: whether a behavior is present or absent at certain time point. This is useful for investigating behaviors that are continuous or difficult to count.

Usually, there are few software tools available to help tutors in recording data from ABA sessions, so recording data on paper is widespread, limiting the possibility of quick and powerful analysis.

3 Related Work

In recent years, various data collection systems for monitoring children with autism have been proposed. However, they mainly rely on systems specifically designed to observe behaviors and not to monitor learning trends. Leroy [16] presented a digital library of data related to appropriate and inappropriate behavior of children with autism in different social settings during the therapy, which includes video recordings. Decision trees and association rules provided more detailed insight into high and low levels of appropriate and inappropriate behavior.

DDtrac is software for educational programs of children with autism, and supports the collection and analysis of data for documenting the progress of children with autism [19]. DDtrac supports both quantitative (numeric) and qualitative autism data collection. The quantitative data that can be collected include instructional data, social data and behavior data.

The Kellar Instructional Handheld data (KIHd) System [20] is a real-time data collection tool for gathering instructional data about students diagnosed with autism. The software presents a database-driven handheld-based data collection and analysis system.

Both software programs, DDtrac and KIHd, require manual input of data from the therapists in order to analyze them. By contrast, our software automatically records and stores most of the data, such as programs, levels, categories, articles, progressive number of trials, errors and time elapsed between the trials as well as the child's response. Tutors complete the evaluation of the exercise by simply pressing a key on the keyboard (to insert the type, full or partial -- and percentage of prompt provided,

i.e., 100, 80, 50, 20 or 0). In this way, data can be homogeneously analyzed through the data analysis tool presented here.

Another tool is ABPathfinder (http://www.abpathfinder.com/) a cloud-based software program that improves the efficiency and effectiveness of ABA therapy by reducing paperwork and improving data outcomes. All the complex processes of ABA therapy, including data collection and charts, are specifically created for this therapy. Unfortunately, ABPathfinder is a commercial product representing additional expenses for the family of an autistic child, already burdened with the cost of the behavioral intervention.

Recently Tarbox et al. have compared the use of a PDA (Personal Digital Assistant) for collecting behavior data with traditional pen-and-paper data recording. Their conclusions were that data accuracy are equal for both formats, but traditional data collection was faster [21]. However, we claim that rapidity mainly relies on the software features and the usability of user interfaces (UIs) as well as on the subjective user's ability to insert data. The use of gestures would make the process more natural. In addition, having electronic data enhances the evaluation and assessment phases.

Lastly, scientists have applied data mining techniques in order to analyze large sets of stored ABA data. In Freeman [22] the relation between physiological events, environmental factors, and the occurrence of problem behaviors are analyzed using the data mining system LERS (Learning from Examples based on Rough Sets).

4 Data Gathering/Collection

The proposed learning analytic tool is a web-based application that allows ABA tutors and parents to visualize information about the learning trends of children executing the ABA intervention with a specific software. In this section we briefly describe the didactic software used for data collection to better understand the kind of data.

The ABA-based didactic software implements matching, receptive and expressive programs. Each program is executed according to DTT (Discrete Trial Training) levels and each trial can be repeated several times. For each trial, the percentage of prompt provided, the occurrence and type of errors, the independent trials, and the use of reinforcement are recorded. A didactic session of about 2.5 h can produce a large amount of data since the trials are very short. Data automatically collected during each session are stored in a database and available real-time in statistical format during the exercise. This provides the tutors with a summary of data taken at different times or places from different educators, very helpful for monitoring the performance trend at any time.

The behavioral data types used in our analysis mainly refer to an event sampling, as previously defined, i.e., how many times the behavior occurs in a defined range of time. The possible behaviors are related to the learning: articles and categories mastered, successful trials, errors and prompts. The learning analytic tool elaborates data gathered by the didactic software and shows it through graphs and charts to make monitoring and evaluating a child's progress quick and easy for tutors so they can modify the objectives of the ABA programs if needed, to improve learning or behavior outcomes.

5 The Learning Analytic Tool

The tool supports tutors in data analysis, aggregating and extracting data automatically according to the preferred view and displaying it in a more intuitive rendering. The tool is a web-based application implemented in PHP and JavaScript that relies on an SQL database for extracting session data. The implementation makes use of the jQuery framework.

The application is embedded in the didactic software environment for the tutor's benefit, making it easy to analyze a particular section of data before starting a didactic session, offering a quick look at the child's learning progress or difficulties. This possibility is also helpful for assessing the materials before the session starts. The learning analytic tool can also help the consultant who coordinates the ABA intervention, to prepare reports before team meetings and assess future refinements. To efficiently analyze the large amount of data collected, different functions could be developed to provide data views for the educators, according to their expertise as well as needs. Thus we decided to base the functions' design on what tutors usually look for when analyzing the child's data of the ABA sessions, traditionally recorded on paper.

During the learning activities, tutors are mainly interested in collecting data that could reveal a positive/negative learning trend and increased/decreased occurrence of problematic behaviors. Periodically tutors need to assess the intervention based on the current status of the child. For this they need to analyze data related to learning: 1) period of time it took to acquire a certain article, thus knowing the dates of its introduction and mastery; 2) number of articles mastered in a certain period; 3) occurrence of problem behaviors and 4) quantitative/qualitative evaluation of use of tutor's prompt during the exercises. All this data related to the children's trials are recorded by the ABA-based didactic software.

Therefore, the proposed learning analytic tool integrated in the didactic software provides a basic set of queries that tutors usually need in order to monitor the child's learning progress and that are arduous to implement manually. However, if the predefined queries implemented are insufficient, it is possible to save raw data to refine the view and the analysis as preferred.

The tool supports multiple types of charts in order to show the child's progress. Stacked bar, multi-line and single-line charts are used to show the results of different queries. To implement these charts we used Highcharts[1], a library written in JavaScript, which offers intuitive and interactive charts to web sites or web applications. Highcharts library is supported by the most recent versions of browsers, including Safari. This library allows users to interact with charts providing access to the information according to levels of increasing/decreasing complexity, i.e., obtaining detailed or overall information. For example, if there is more than one data series, the user can click on one of them to hide or unhide it, selecting what to highlight. Indeed, when 'on mouse over' events above the charts occur, a tooltip text is shown with information on each point and series following the movement of the mouse over the

[1] http://www.highcharts.com/

graph. Another interesting feature is that by zooming in (in the X or Y dimensions) on a chart, it is possible to closely examine a particular portion of the data.

Two buttons on the upper right of each chart allow the user to manage data shown by the tool, for instance to produce reports. One button automatically provides a print version of the chart, the other button handles data saving in various formats: PDF file, image PNG or JPEG, or SVG representation.

Finally, we implemented an additional Javascript function that allows users to automatically export and download all the data extracted by the learning analytic tool into CSV format. This feature is particularly important since it allows the tutors to obtain and manage raw data on the children's learning, to permit further elaboration processes not provided by the tool.

To access the learning analytic tool, the tutor typically logs in to start an ABA session via the didactic software, selecting a child to work with. After login, s/he can decide to access the didactic software or the learning analytic tool by pressing a button on the UI. In this way the data analysis tool shows only data related to the selected child. The first page of the tool allows the tutor to choose from among six different predefined queries. For each query the user can set a time interval by specifying the start and the end date of interest. The queries are described in detail in the following:

1. **Articles:** Shows a table with the list of the articles used in the didactic software sessions executed in the selected time interval, detailed in a monthly resolution. For each article, the table reports the number of trials performed on each article and the ABA programs in which the article has been totally or partially mastered. Clicking one of the articles opens a pop-up with more detailed information, such as the date of the first and last use. A button allows downloading data selected in a CSV file.
2. **Categories:** Shows a table with the list of categories used in the didactic software sessions executed in the selected time interval, detailed in a monthly resolution. Clicking one of the categories produces a pop-up with more detailed information, such as the date of the first and last use of the category and the list of the articles used. A button allows downloading the data selected in a CSV file.
3. **Articles Mastered:** This query reports the number of articles mastered by the child, the number of sessions performed and their ratio. The query results are created in tabular and graphic formats. In Fig. 1 the upper line (blue) shows the number of articles mastered vs time, and the lower one (red) represents the number of articles mastered compared to the number of sessions completed. The number of sessions is an important parameter in such an analysis since it can highlight a child's greater or lesser need in terms of frequency of work (session hours) in order to obtain good results. The chart can be dynamically modified to highlight specific information, selecting only the line of interest.

   As previously mentioned, for all the graphs on the upper right side of the chart two buttons are available (see Fig. 1): one for the print version of the chart, and the second for exporting/downloading it as a PDF file, a PNG or JPEG image or an SVG vector image. It is also possible to download all the data extracted by the query into CSV format.

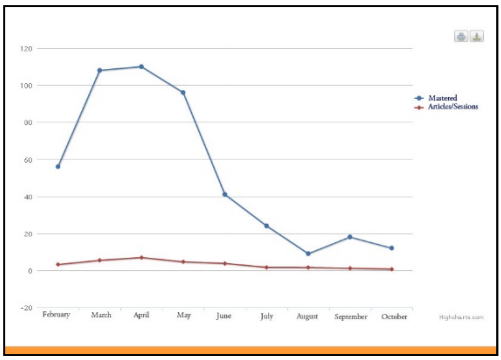

Fig. 1. Graph of number of articles mastered vs time

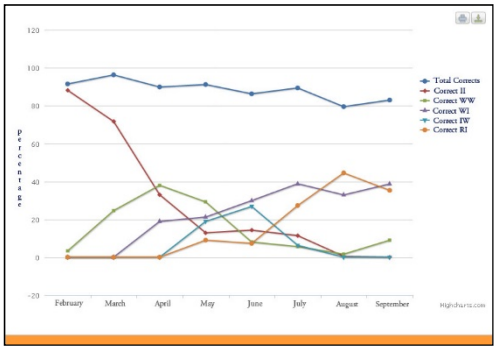

Fig. 2. Graph of correct trials vs time

4. Successful trials: The query returns the percentage of correct independent trials performed by the child (without prompt) through the ABCD software. If necessary, the tutor can access an additional table available through a pop-up menu with the list of the articles used in each trial. Information is shown as a textual table and as a chart. An example of the chart produced by this type of query is shown in Fig. 2: the acronyms refer to matching (M) and receptive (R) programs indicating whether combinations of Images (I) and Words (W) are used, as described in the Introduction of this paper. It is possible to print or download the chart in different format, and to download raw data in CSV format. The chart can be dynamically modified to highlight specific information selecting only the line of interest.

5. Error types: The query provides the percentage of different kinds of errors (i.e., error performing the exercise, auto-stimulation, no collaboration). It is possible to have information on which article was under acquisition when the child made a specific error, at which level, and so on (Fig. 3). The chart is interactive and allows highlighting specific information. It is possible to print or download the chart in different format, and to download raw data through a CSV file.

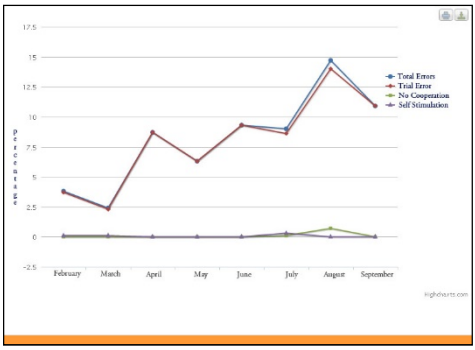

Fig. 3. Graph of error types vs time

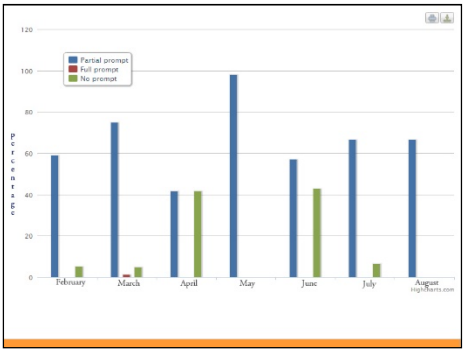

Fig. 4. Graph of prompts provided vs time

6. Prompts provided to the child: The query returns the percentage of occurrence of different levels of prompts, aggregated by relevance, i.e., Full prompt, Partial prompt and No prompt. The didactic software allows easy recording of prompt levels by pressing a key on the keyboard; keys from 1 to 5 are associated with percentages from 0% to 100%. All the data information is shown as a textual table and as a chart; an example of outcome is shown in Fig. 4. The chart is the result of grouping the prompts by the three abovementioned classes. If a more detailed view is desired, this query provides information (in table format) about the articles for which one or more prompts have been needed. For this type of query, a daily view of the use of prompts is also available, if required. As for the previous queries, it is possible to dynamically modify the chart to highlight specific information, print or download it in different format, and to download raw data in CSV format.

The tool can also be used outside the didactic software environment, although the database exploited is certainly the one collected by that software. This can be useful for offering an overview of the learning results to different subjects involved -- also indirectly -- in the intervention. In this case, after the log-in phase, it offers a look at the data of all the children associated with the logged-in tutor, since a specific child

was not selected. In this way it is possible to process the data of all the children together, in order to obtain information extended to the whole working group.

5.1 Accessibility of the Learning Analytic Tool

The learning analytic tool is mainly based on visual features, but we focused especially on providing semantic content in a format fully usable by everyone. In fact, while developing and designing the visually-oriented user interfaces, we kept in mind accessibility aspects during the design process. We provided an alternative way to present content based on tables to render the graphical data in a textual format. This solution, aimed at making the graphical data accessible, was useful for observing the data from another point of view, enriching the analysis.

Due to their visual nature, charts present a real problem for people with visual impairments, especially for the blind. Thus, to be accessible charts should be presented with additional kinds of information, readable by assistive technologies. Section 508 (http://www.access-board.gov/508.htm) and Web Content Accessibility Guidelines - WCAG (http://www.w3.org/TR/WCAG20/) both require that all non-decorative and non-textual content should be made accessible to assistive technologies. Thus, if the data in a chart is crucial for understanding the content of a Web page, a text description has to be added. In the case of the graphical charts used by the learning analytic tool, a numeric table replicating the chart data has been added to provide an alternative version of the data shown. This solution resulted useful for providing granular information, which can be more generally observed through a graphical show. In order to make accessible the data included in the tables, we used the traditional HTML tags such as TH, TD and SUMMARY, which provide valuable meta-information about the table. We tested interface accessibility using the screen reader Jaws (http://www.freedomscientific.com/), which was able to correctly read the entire content of the tables.

6 Conclusions

The work presented herein is a learning analytic tool, web-based and implemented in conjunction with a didactic software program that enables technology-enhanced ABA intervention for children with autism. ABA intervention relies on the systematic collection of data in which the environmental variables involved in a specific behaviour are carefully annotated. Its efficacy is steadily monitored by analyzing this data. The learning analytic tool favors this monitoring by automatically extracting, aggregating and visualizing the children's progress, based on data from the didactic software sessions. Data are visualized in a different way, through charts and graphs, allowing the user to further explore them in an interactive modality. In this way, the application provides tutors with accurate real-time monitoring of children's learning and behavior, allowing them to more accurately tune and personalize the intervention for each child.

The learning analytic tool is open source and freely available. It was designed involving all members of an ABA team in order to better respond to their needs when performing data extraction and processing from the large amount of automatically collected data. A set of predefined queries has been implemented for retrieving the most relevant information on a child's performance over time, presented in an intuitive and interactive way, using tables and charts.

The ABA tutors were involved in the design and test phases of the tool to better understand the type of analysis needed as well as to improve the UI usability. Results from an online questionnaire showed that this tool is well-appreciated by 12 ABA professionals using the software since it reduced the effort of manually retrieving the large amount of data produced in ABA sessions: each tutor is able to view the child's performance in real time, useful both at the beginning of each intervention (to rapidly see previous progress) and for child assessment..

As future work, a larger set of users would be recruited to collect more feedback and suggestions, to further enrich the monitoring tool.

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References

1. Sicile-Kira, C.: Autism Spectrum Disorders: A Complete Guide to Understanding Autism, Asperger Syndrome. Pervasive Developmental Disorder and Other ASDs. The Berkley Publishing Group, New York (2004)
2. Lovaas, O.I., Smith, T.: Intensive behavioral treatment for young autistic children. Advances in Clinical Child Psychology 11, 285–324 (1988)
3. Rogers, S., Vismara, L.: Evidence-based comprehensive treatments for early autism. Journal of Clinical Child & Adolescent Psychology 37, 8–38 (2008)
4. Leaf, R., Baker, D., McEachin, J.: Sense and Nonsense in the Behavioral Treatment of Autism: It has To be Said. Chapter 1: What is ABA? DRL Books Inc., New York (2008)
5. Bernard-Opitz, V., Ross, K., Nakhoda-Sapuan, S.: Enhancing social problem solving in children with autism and normal children with computer-assisted instruction. Journal of Autism and Developmental Disorder 31(4), 377–384 (2004)
6. Bosseler, A., Massaro, D.W.: Development and evaluation of computer-animated tutor for vocabulary and language learning in children with autism. Journal of Autism and Developmental Disorders 33(6), 553–567 (2003)
7. Moore, M., Calvert, S.: Brief report: Vocabulary acquisition for children with autism: Teacher or computer instruction. Journal of Autism and Developmental Disorders 30(4), 359–362 (2000)
8. Buzzi, M.C., Buzzi, M., Rapisarda, B., Senette, C., Tesconi, M.: Teaching Low-Functioning Autistic Children: ABCD SW. In: Hernández-Leo, D., Ley, T., Klamma, R., Harrer, A. (eds.) EC-TEL 2013. LNCS, vol. 8095, pp. 43–56. Springer, Heidelberg (2013)
9. Deno, S.L.: Developments in Curriculum-Based Measurement. The Journal of Special Education 37(3), 184–192 (2003)

10. Anderson, S.R., Romanczyk, R.G.: Early Intervention for Young Children with Autism: Continuum-Based Behavioral Models. The Journal of The Association for Persons with Severe Handicaps 24(3), 162–173 (1999)
11. Corsello, C.M.: Early intervention in autism. In: Infants & Young Children, vol. 18(2), pp. 74–85. Lippincott Williams & Wilkins, Inc. (2005)
12. Dawson, G., Zanolli, K.: Early intervention and brain plasticity in autism. Novartis Found Symp. 251, 266–274 (2003); discussion 274–280, 28–97
13. Evidence based practice and Autism in the school. A guide to providing appropriate interventions to students with autism spectrum disorders. NAC-National Autism Center. Massachusetts (2009) ISBN 978-0-9836494-1
14. Klin, A.: Listening preferences in regard to speech in four children with developmental disabilities. J. Child Psychol. Psychiat. 33, 763–769 (1992)
15. Leroy, G., Irmscher, A., Charlop-Christy, H.M., Kuriakose, S., Pishori, A., Zurzman, L., Ash-Rafzadeh, A., Seffrood, M., Buxton, S.: Data mining techniques to study therapy success with autistic children. In: DMIN, pp. 253–259 (2006)
16. Moderato, P., Copelli, C.: L'analisi comportamentale applicata Seconda parte: metodi e procedure. Autismo e Disturbi Dello Sviluppo 8(2), 191–233 (2010)
17. Calouri, K., Hamblen, A., Drill Book, E.: Project Pace, Inc. (1996)
18. Kearney, A.J.: Understanding applied behavior analysis: an introduction to ABA for parents, teachers, and other professionals. JKP essentials. Jessica Kingsley (2008)
19. Gregg, D.G.: Using Data Collection and Analysis to Improve Outcomes for Children with Autism. The Voices and Choices of Autism 1(3) (2009)
20. Shi, L., Graff, H., Wang, S.: Design and Development of KIHd System: A Data Collection and Analysis System for Teachers and Parents Working with Children with Autism and Other Disabilities. In: Society for Information Technology & Teacher Education Int. Conference, pp. 4231–4236 (2006)
21. Tarbox, J., Wilke, A.E., Findel-Pyles, R.S., Bergstrom, R.M., Granpeesheh, D.: A comparison of electronic to traditional pen-and-paper data collection in discrete trial training for children with autism. Research in Autism Spectrum Disorders, Elsevier 4(1), 65–75 (2010)
22. Freeman, R., Grzymala-Busse, J., Harvey, M.: Functional behavioral assessment using the data mining system-strategies for understanding complex physiological and behavioral patterns. J. Intell. Inf. Syst. 21(2), 173–181 (2003)