Using Cosmo's Learning System (CLS) with Children with Autism

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ABSTRACT

A 10-week study using a computerized learning tool called Cosmo's Learning System (CLS) was conducted with 6 children with autism. Each subject received two half hour sessions a week focused on developing identification of color, shape, number, directions, prepositions, and written words as well as sequencing skills and discrimination of relative size and amount. An assessment was created to allow stringent evaluation of the child's initial skills and progress in the therapy. All subjects demonstrated improvements on the post-test in all content areas except color identification. Children learning prepositions and direction improved an average of 20%. Similar gains were made in written word reading. Children learning relative size/amount improved but had difficulty understanding the concept 'same'. Subjects showed an increase in the number of trials completed and required less prompting to respond in the last 4 sessions. Although both verbal and non-verbal children made gains, a greater degree of initial comprehension led to greater success. These first results using Cosmo's learning system are very promising. Further research with more subjects is proposed.

INTRODUCTION

Research comparing computer-based with non-computer based instruction for children with Autism Spectrum Disorder (ASD) has demonstrated greater effectiveness when children use the computer than with traditional teacher-only methods (Bernard-Opitz et al, 1990). Some existing research has found that autistic individuals consider interactions with a computer less stressful and more engaging than interactions with people, leading to increased learning (Moore & Calvert, 2000). Whether it is the presentation of material in the context of a computer display, or the decreased social interaction required, children with ASD demonstrate greater accuracy and likelihood to respond using a computer to improve skills when compared with more traditional methods (Chen & Bernard-Opitz, 1993). In short, "computers are successful teaching instruments for children with autism due to their multisensory information, controlled and structured environments …and their ability to individualize to each student" (Hetzroni & Tannous, 2004, pg. 96)

Other language-impaired populations (e.g., patients with aphasia) have demonstrated a number of impressive language-based improvements as well as maintenance of gains using computerized instruction (Linebarger et al.,2001; Boser et al., 2000). However, only a few recent studies have investigated the effectiveness of computers for improving language and communication skills in ASD (Yamamoto & Miya, 1999; Hetzroni & Tannous, 2004).

Improving communication and language in autism may require a combination of different techniques, although careful analysis and comparison of available therapies indicates that some form of discrete trial training or Applied Behavior Analysis (ABA) format forms the best basis for children with ASD who are learning new skills (Heflin & Simpson, 1998). The CLS can easily be adapted to an ABA format. The hallmarks of ABA: measurement of behaviors (i.e., responses made), antecedents to behaviors (i.e., stimuli presented) as well as ongoing performance can all be monitored in CLS. While the computer delivers immediate response-based feedback, the therapist can also adjust and/or amend this feedback as necessary (e.g., delivering a stronger food-based reward). One previous study used an extensive computer-based assessment tool to evaluate ABA-style vocabulary training in a low-functioning nonverbal subject (Boser et al., 2002). This study demonstrated the value of the computer's storage of all characteristics of a trial including location, features, and names of all responses and items displayed. For the current study, we designed a specific assessment tool to allow access to this valuable information. Although there are numerous advantages of computer-based ABA delivery, including better trial randomization and less errors in performance calculations, studies of computer-based ABA therapy are rare (Gordon, Glatzer, Boser, 2001).

Our main objective in this study was to evaluate the efficacy of CLS as a therapy tool for improving receptive language in children with autism. We hypothesized that the preference of children with ASD for computer-assisted instruction and the adaptability of the program to a discrete trial ABA format may predispose them to attend more to the Cosmo's Play and Learn activities.

METHOD

GENERAL PROCEDURES

All subjects were pre-tested for a week, using both computerized assessments as well as non-computerized (traditional) evaluations of the skills targeted in the therapy. Traditional evaluation included using manipulative items and table-top tests in a one-to-one format between teacher and student. Since there were no obvious differences in performance between computer vs. non-computerized presentation we used the computer testing to determine the course of therapy and main focus of content. We then completed two half hour therapy sessions a week with the computer, a therapist, and a member of AnthroTronix research staff for a period of 8 weeks. A final week was dedicated to post-therapy assessments, for a total time at the school of 10 weeks. The research staff maintained the computer settings, collected additional data using data sheets, video-taped the sessions for later analysis, and downloaded data for backup and integration into a central database. Video tape recordings were catalogued and copied as a further back-up of each session.

SUBJECTS

A group of 7 male children with autism, 6-13 years old, were targeted to participate. Based on prior neuropsychological testing, all subjects had a diagnosis of Autism/PDD (made through DSM IV criteria) and a cognitive age approximately 2 -5 years behind their chronological age.

All currently attending the Linwood School in Ellicott City, Maryland. Five of these children were 10 and under and two were 12-13 years of age. Three had significant language output and two were starting to learn to recognize some written words. However, the other four were struggling with productive and receptive vocabulary. Permission to participate was granted by the parents of the children through their signature of an IRB-approved letter. Privacy was maintained by creating subject IDs and storing the corresponding names and background data in a separate location.

Table 1: Subject Table

Subject ID	AGE (years;mos)	LANGUAGE	Comments	CLS Activity Completed(p. 5)
AC-01*	6;7	Verbal	Attention problems	All
AD-02	12;10	Single words	Whisper-voice, some comprehension	1, 2, 3, 4, 6, 7
AI-03	11;05	Non-verbal	Very active; poor attention; difficult to test/evaluate	1, 6, 7
AJ-04	13;10	Echolalic,	Lethargic; little comprehension	1, 6, 7
AM-05°	9;04	Non-verbal	Dropped out; poor testing	0
AV-06*	10;08	Verbal	High functioning, working memory problems	All
AZ-07	10:01	Prompted words	Attention problems; difficult to test due to dietary illness	1, 6, 7

*indicates that the subject completed all difficulty levels of the tasks ° subject dropped out of study

COSMO'S PLAY AND LEARN SOFTWARE

Cosmo's Play and Learn software is a family of educational computer packages that target children of developmental ages 2-8. CLS consists of a computer interface device (a monitor and mission control) and educational software. Using Mission Control, a keyboard-sized interface with built-in microphone and four aFFx activators designed to interact with a computer or control CosmoBot, children empower a virtual robot to explore a playground filled with activities. The main character of the software is Cosmo, a virtual robot, who motivates and engages the children. Created in conjunction with educators, therapists, and assistive technology practitioners, the software allows the facilitator to target specific goals and track the child's progress. CLS has a comprehensive curriculum guide and magnetic manipulatives to reinforce content areas present in the software. The CLS software has data collection that tracks general therapeutic and educational activities.

COSMO'S ASSESSMENT:

Cosmo's Assessment was developed by Dr. Katharina Boser to provide a precise, in-depth measure of student progress before and after using Cosmo's Play and Learn System (CLS). The assessment tool was created to measure knowledge of all content areas of the computer-based therapy. The tool is innovative because it takes into account fundamental issues relevant to working with children with severe learning impairments, it can be modified for other content goals, and provides accurate measures for reporting progress.

One learning principal that the assessment addresses is the problem of response interference that lower functioning subjects exhibit in learning new skills (for detailed discussion of interference in stimulus control see Green, 2001). For example, a subject may continue to choose a learned item and ignore new target stimuli. Alternatively, they may choose items at a location that was previously reinforced. One method to counteract such interference, is to avoid consecutive testing of the same item. In this study, we adopted best practices for establishing conditional discrimination in teaching procedures in this population as described in Green (2001) among others.

Cosmo's Assessment is computer-based and facilitated by an adult. The assessment measures:1) identification (ID) of **color**, 2) **color sequencing** 3) **shape ID**, 4) **number ID**, 5)identification of the 28 **written text words** corresponding to the content, 6) discrimination of **relative size** (bigger/ smaller/same) and 7) **relative amount**, e.g., more/less/same, 8) **directions** (up down right left); 9) identification of **prepositions** (inside, outside, behind, in front, over under). Figure 1 below provides a visual depiction of a typical screen for the 9 assessments.

Target items were randomly presented in four different locations, preventing chance correct responses with a small sample. The output data provide information regarding each trial, including not only the target location and content but also all other response options. This allows the tester to prevent guessing and to evaluate response strategies. For children with lower ability level a 2-item version of the task was shown in which 2 of the 4 boxes displayed were empty.

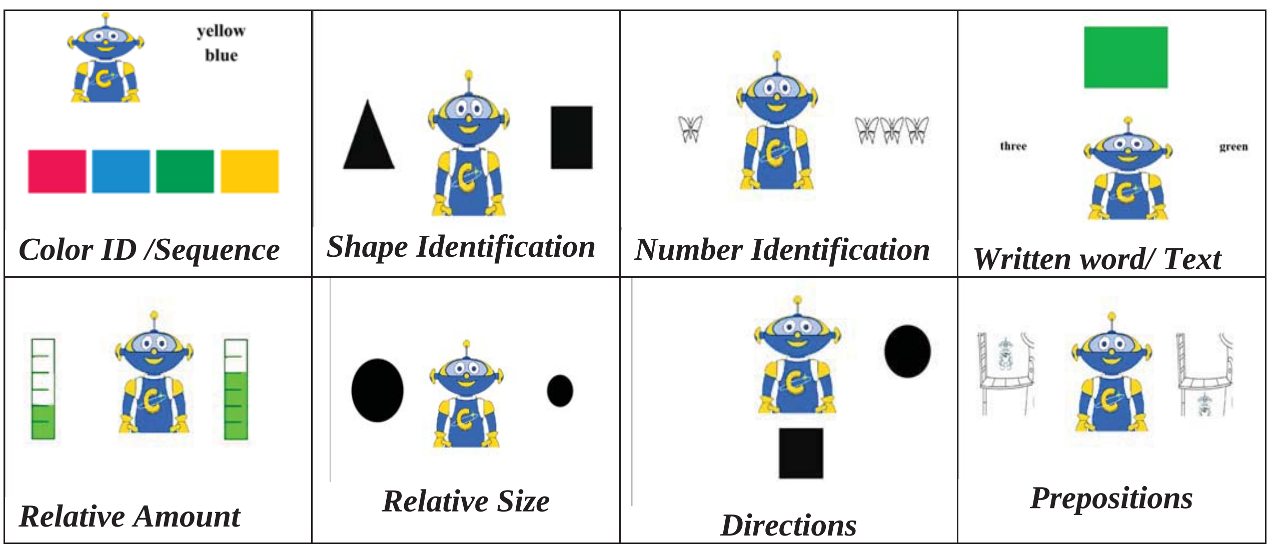


Figure 1: Assessment Screens

Cosmo's Assessments consisted of 10-12 trials unless the child made three consecutive errors. If three consecutive errors are made, the facilitator exits the program. Some children received a choice of rewards to maintain interest in Cosmo's Assessment and the computer as necessary. These rewards were initially presented every trial and then faded as the child became increasingly engaged. Breaks were provided as necessary. No feedback was provided for responses except to maintain attention to the task (e.g., "good sitting", "good looking").

COSMO'S PLAY AND LEARN (CLS) THERAPY

Therapy consisted of 2 half hour sessions with the CLS for 8 weeks. Therapists at Linwood worked with our staff to use the system and help the children with any possible behavior issues. Linwood therapists transported children to and from their individual classrooms to a separate quiet area where the computer system was maintained. The children were encouraged to use the "free play" sessions as breaks where needed.

During the therapy with CLS, text remained 'on' and available during all training sessions (Figure 2). Children were allowed maximum time to respond; but with adjustment of timing of Cosmo's prompts for each child/situation. Therapists were encouraged to provide cues as they would during a normal therapy session to keep the child engaged and on task. Teachers from the Linwood School were allowed to remain in the room, aiding only when a child's attention waned significantly. Over time, Cosmo provided the main source for cues and help to the child. The program incorporates in a lot of reinforcement for correct responses (e.g., sound, movement of animated characters or symbols).

Feedback in CLS was targeted, immediate and leveled. It increased in amount and informativeness as the child continued to make an error (less to more prompting). First, a 'try again' response was given, then the question is repeated and a visual cue is given. After a third incorrect response, Cosmo provides the correct answer and a new trial begins. If the child needs more than 3 'give away' cues (highest cue), the therapist was encouraged to move on to either 'freeplay' for that module or a new module, or perhaps try a 'break' using manipulatives. Otherwise, 10-12 trials in each module was attempted

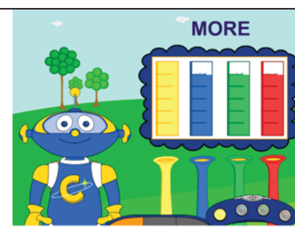
 *1. Blowing Bubbles*	 *2. Bubble-a-Tron*	 *3. Bubble Recipes*	 *4. Popping Bubbles*
 *5. Playing Tag*	 *6. Number Jumping*	 *7. Puzzle-a-Tron*	 *8. Free Play*

Figure 2: Therapy Screens

The therapy involved a variety of activities in each of the content areas. The following descriptions provide a brief description of the activities for each content area. See Figure 2 for visual depiction (screen shot). Table 1 lists the activities each student completed.

1. Blowing Bubbles: The child learns colors by blowing red, yellow, blue or green bubbles when they press on the correct mission control activator. Difficulty is increased by asking the child respond to two color names at once (color sequencing).
2. The Bubble-a-Tron: In the Blowing Bubbles with the Bubble-a-Tron activity, bubble sizes help illustrate the sometimes subtle differences of “bigger,” “smaller,” and “same.”
3. Bubble Recipes: Following auditory cues regarding relative amount the child must measure the bubble solution very carefully into beakers over the Bubble-a-Tron.
4. Popping Bubbles: Children must hold down the correct mission control activator until Cosmo pops the bubble in the correct location: up, down, left and right.
5. Playing Tag: A virtual game of “Tag” introduces and/or reinforces basic prepositions related to space: under, over, inside, outside, in front of and behind. Children must press the correct activator to move Cosmo in the correct direction to catch his friends, hiding in the targeted location. Task difficulty is increased by changing features and numbers of distracters.
6. Number Jumping: Friends in clusters of 1, 2, 3, 4 or 5 fly above each Space Animal. Cosmo asks the child to help his friends jump over a certain number of flying friends. Once they have been caught, they will do a “counting off” animation and fly off screen. Task difficulty is increased by changing features and numbers of distracters.
7. The Puzzle-a-Tron: Puzzles created by a Puzzle-a-Tron introduce the basic shapes: circle, square, triangle and rectangle. Cosmo asks the child to help his friends jump over the correct shape. Task difficulty is increased by changing features and numbers of distracters.
Free Play: Each module provides an opportunity for the child to explore and learn without assessment, driving their own learning (e.g,. create your own bubbles or recipes, etc.).

USE OF ‘CAPS’

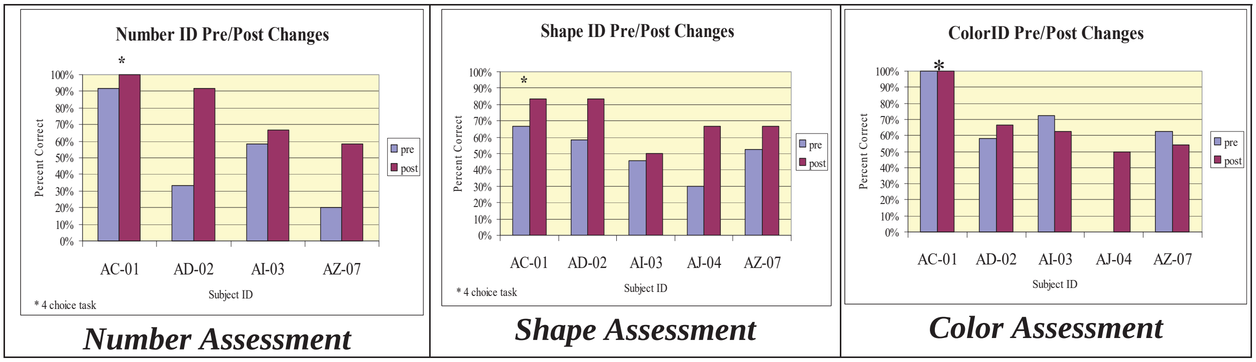
Caps were designed to cover the colored mission control activator boxes for identification tasks where color was not the specific target, i.e., the shape and number tasks. The caps focused the students’ attention away from the colored buttons and toward the corresponding ‘friends of Cosmo’ lined up on the bottom of the screen in these tasks. The caps were small clear plastic tops into which a small picture of Cosmo’s friends was inserted. By eliminating any distracting information, the child was better able to make a direct link between making the specific friend ‘jump’ to catch the correct number or shape and the activator button they needed to press.

RESULTS *(please refer to figures 3-6 on the following page)*

Most subjects demonstrated improvements at post-testing in at least one content area except color identification (Figure 3). Note that unless otherwise indicated the task was a 2-choice discrimination (i.e., chance performance is 50%). Subjects learning relative amount and size (CLS therapy # 2 & 3) improved in understanding relative terms (e.g., bigger, more) but not ‘same.’ One nonverbal subject (AD) demonstrated a large percentage increase in number ID (from 34%-92% correct) and shape ID (59%-83% correct). AC and AV, who participated in preposition and direction therapy (CLS # 4 & 5) improved an average of 20%. Similar gains were made in text reading (Figure 4). AV demonstrated an equally large percentage increase in his ability to repeat color sequences at post testing from 35%-83% correct. Subjects AV and AC who completed relative amount (CLS #3) struggled with the notion ‘same’ but improved for ‘more’ and ‘less’ (e.g., from 40%-100% correct). Unlike AD (Figure 5), both AC and AV remained very good at understanding relative size (CLS #2) terms ‘bigger’ and ‘smaller’ (92-100%), but both struggled with ‘same’ (50-67% at post-test).

Subjects AD, AJ and AI demonstrated an increased number of trials that required no prompt or one prompt (e.g., “try again”) in the final 4 sessions of therapy. Figure 6 showed the difference between the number of trials requiring prompts for the first 4 sessions (‘pre’) and those in the final 4 sessions (‘post’). The amount of trials completed per session increased from pre to post sessions for most subjects. AJ’s trials increased from 19 to 40 for number ID. AI’s trials increased from 65 to 127, AJ’s from 74-115 trials and AD’s increased from 44 to 128 trials for Shape ID.

RESULTS FIGURES



*4-choice task

Figure 3: Identification tasks; number, shape and color

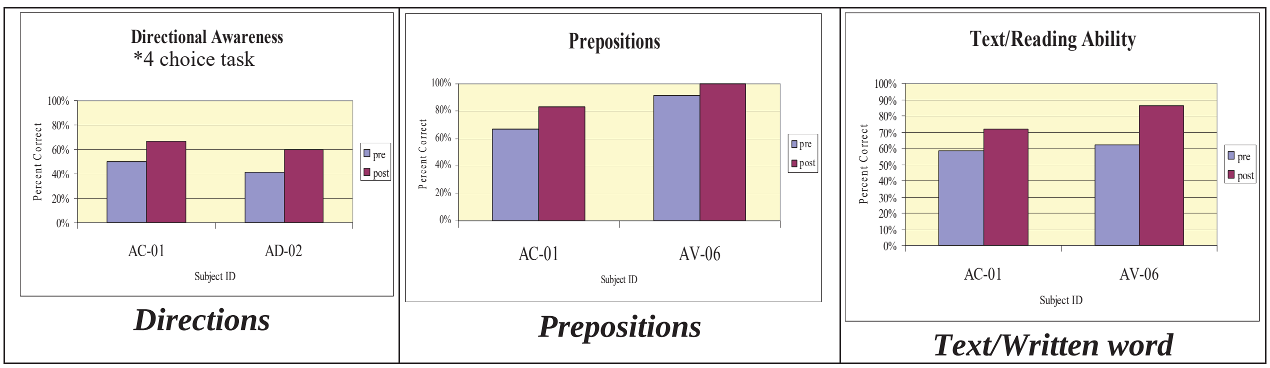


Figure 4: Directions, prepositions and text improvement for AC and AV

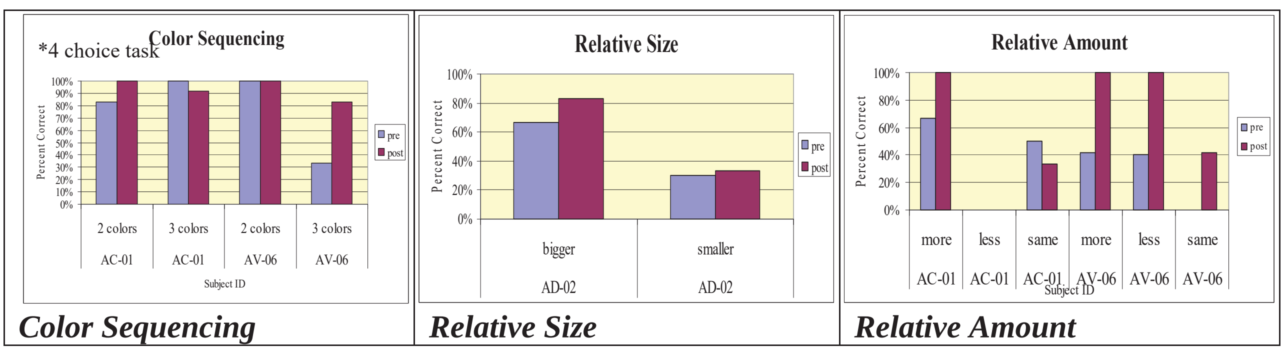


Figure 5: Color Sequencing, Relative Size and Quantity

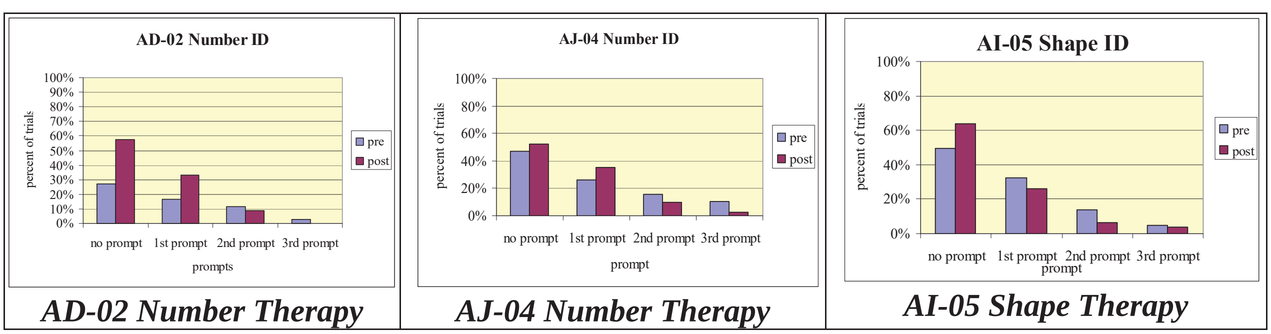


Figure 6: Therapy data for AD, AI and AJ

DISCUSSION

Improvements were found in all areas targeted by the CLS, except color identification. This is not surprising given known research on the difficulty of teaching and learning color terms which are categorical in nature and subject to categorical perception (Bornstein, 1985; Rosch, 1975). Unlike shape and number, color also refers to a characteristic of an object that can change its properties in subtle ways depending on the object. The difficulty subjects faced with understanding the term ‘same’ compared with learning the terms ‘more/less’ or ‘bigger/smaller’ may also be due to the relative conceptual difficulty of the term. Judging sameness or similarity is like an analogy and thus more complicated than making a direct visual comparison such as ‘more’, ‘less’, ‘bigger’, ‘smaller’ (see Gentner & Markman, 1995).

The fact that even lower functioning children AJ, AZ and AI made some improvements in receptive knowledge, and learned to respond more over time, using CLS is encouraging. AJ and AI demonstrated these improvements more through the decreased necessity of prompts than in large pre-post gains. AZ was the one child who missed some therapy due to illness, yet he seemed to make the gains toward the end of the therapy.

CONCLUSION

ASD is a lifelong neurodevelopmental disorder. Early intervention has been prioritized because of evidence that it can make a significant difference to the individual's development (Butter et al., 2003). While even aggressive and early intervention is unlikely to change the diagnosis (Howlin, 2003), it can affect the individual’s eventual success across all core life domains (Butter et al., 2003). A computerized tool such as Cosmo’s learning system has the potential to make great improvements in a child’s quality of life and in the therapists ability to monitor and reward progress. Results from this initial study encourage us to investigate CLS further as a very promising learning tool that engages students in longer learning intervals.

The ultimate goal for the students is to transfer skills learned to real-world situations involving activities of daily living (ADL) and everyday interactions with parents, teachers, and peers. Multimodal control, like other enriched computer environments, will add to the vividness of these learning experiences as well as to their ecological validity, which, in turn, is expected to enhance transfer of training (Trepagnier et al., 2006). We are working toward developing the software as part of a larger system that includes CosmoBot, an interactive robot and extension of ‘Cosmo’ from the software (Brisben et. al., 2006). This will allow us to include joint attention, imitation, and other social and communication skills in the child’s learning repertoire. Our results suggest that continued development of stimulus presentation, prompting methods as well data collection and presentation will be crucial in the continued enhancement of CLS as a valuable learning tool for children with autism and those working who work with them.

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