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Effects of a Computer-Based Intervention Program on the Communicative Functions of Children with Autism

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This study investigated the use of computer-based intervention for enhancing communication functions of children with autism. The software program was developed based on daily life activities in the areas of play, food, and hygiene. The following variables were investigated: delayed echolalia, immediate echolalia, irrelevant speech, relevant speech, and communicative initiations. Multiple-baseline design across settings was used to examine the effects of the exposure of five children with autism to activities in a structured and controlled simulated environment on the communication manifested in their natural environment. Results indicated that after exposure to the simulations, all children produced fewer sentences with delayed and irrelevant speech. Most of the children engaged in fewer sentences involving immediate echolalia and increased the number of communication intentions and the amount of relevant speech they produced. Results indicated that after practicing in a controlled and structured setting that provided the children with opportunities to interact in play, food, and hygiene activities, the children were able to transfer their knowledge to the natural classroom environment. Implications and future research directions are discussed.

KEY WORDS: Autism; functional communication; computers; echolalia.

One of the primary characteristics of autism in children is impaired communication, manifested by delay in development of language, repetitive and idiosyncratic use of language, and impairment in the ability to initiate or maintain conversation (Wetherby & Prizant, 2000). As a result, children with autism experience difficulties in the development of language pragmatics and in the use of functional communication (Beukelman & Mirenda, 1998; Tager-Flusberg, 1993, 1997). The difficulties children with autism have in understanding concepts, assumptions, and communicative intentions and in developing representational thought are all associated with impairment in theory of mind (ToM) (Baron-Cohen, 1988; Tager-Flusberg, 1997). ToM relates to the ability to "predict relationships between external states of affairs and internal states of mind" (Frith, 1989, p. 157). The difficulties associated with ToM may be in understanding, organizing, and using language functions and are often manifested by children with autism in delayed and immediate echolalia and in irrelevant speech.

Echolalia is defined as a repetition of a sentence, or part of a sentence, immediately or later after hearing it (Rydell & Prizant, 1995). Some researchers consider echolalia to be a part of normal language development (e.g., Baltaxe & Simmons, 1977), whereas others see it as a pathological behavior that might interrupt the normal sequence of linguistic cognitive development (Coleman & Stedman, 1974; Schriebman & Carr, 1978). Prizant (1983) asserted that echolalia might interfere with the acquisition of the functions and structure of language among children with autism.

Bloom and Lahey (1978) identify the difficulties in the development of language of children with autism as a disorder in one of the language components (i.e., form, use, or content) or as an interaction between

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them. For children to be able to use language, they need to understand the language code, have the knowledge of objects and events in the world of the speaker and the listener, and be able to decode the relationships between them (Bloom & Lahey, 1978). Exposure to different communicative interactions facilitates the development of successful language abilities. If one or more of the language components are used inappropriately, or if the interaction between them is distorted or not existent, a language disorder occurs. For example, if a child with autism talks about issues out of context, he or she has a disorder in language use. This difficulty in relating to another's state of mind and engaging in conversation is identified as impairment in the development of ToM (Baron-Cohen, Leslie, & Frith, 1985).

If a child with autism has stereotypical speech with expressions that are not related to the situation or the context, his or her speech could be considered a distorted interaction between language components. This operational analysis of Bloom & Lahey (1978) was later defined as echolalia (Prizant & Duchan, 1981; Prizant & Rydell, 1984; Tager-Flusberg, 1992, 1993, 1997). Thus, a distortion in the interaction between language components produces a form of speech that is defined as functional immediate or delayed echolalia.

During the normal development of language, children use various strategies for learning language and communication (Bates, 1976). Those strategies may need to be augmented for enhancing the development of the language functions and communication of children who have autism. Opportunities to interact in an environment containing concrete and structured educational uses of language can provide children with autism with appropriate settings for enhancing the development of language (Mesibov, Schopler, & Hearsey, 1994).

Use of training and practice in controlled environments was found to be effective for children with autism when they were later performing in a natural environment (Alcantara, 1994). Training and practice were used in a study investigating the use of videotaped sessions for teaching elementary school children with autism to purchase groceries in a community setting (Alcantara, 1994): Videotapes were used for training the children in a controlled environment, and after training, the children generalized and transferred the acquired skills and could purchase groceries in community settings (Alcantara, 1994).

Generalization, a strategy used by normal children to acquire language, is often impaired in children with autism, especially when they are required to transfer the learning to new environments and new behaviors (Koegel & Koegel, 1995; Koegel & Rincover, 1977). Children are expected to generalize knowledge gained in one environment to another, to transfer a statement from one situation to another, and to generalize from one stimulus presented to them to another similar or a different stimulus (Lloyd, Fuller, & Arvidson, 1997). Simulated environments that present a controlled and structured setting can be created using multimedia computer-based strategies, which could provide autistic children with an opportunity to train and practice various skills.

Computers are successful teaching instruments for children with autism (e.g., Chen & Bernard-Opitz, 1993; Colby, 1973; Higgins & Boone, 1996; Panyan, 1984). Multisensory interactions, controlled and structured environments, use of multilevel interactive functions, and especially individualized use and independence are some of the features provided that assist children with autism when working with computers. Those functions were found effective for various computer-based interventions (e.g., Bernard-Opitz, 1989; Bernard-Opitz, Ross, & Tuttas, 1990; Chen & Bernard-Opitz, 1993; Panyan, 1984; Yamamoto & Miya, 1999).

Research comparing teacher and computer-based instruction found that of 18 students with autism observed in both teaching methods, only one found teacher-based instruction more effective than the computer (Bernard-Opitz, Ross, & Tuttas, 1990). An additional study found that students with autism provided more accurate answers, performed more often, and demonstrated improved behavior skills after using computer-based instruction than after using traditional instruction (Chen & Bernard-Opitz, 1993). Heiman, Nelson, Tjus and Gilberg (1995) found that the interactive environment provided by the computer enhanced the reading and writing skills of children with autism.

Computers have been found to be effective for teaching children with autism across various instructional skills (Higgins & Boone, 1996; Panyan, 1984). Yet, there is still a need to investigate whether children with autism could learn specific language skills within a structured and a controlled environment and then transfer those skills to a natural setting. Only a few studies have investigated the effectiveness of computers for enhancing language skills (e.g., Yamamoto & Miya, 1999). Moreover, the theoretical and pragmatic aspects of the development of communication and language were not assessed in a computer-based environment. The potential for using computer-based interventions to enhance the communicative functions

of children with autism through practice in a controlled environment and transference to a natural environment still needs to be investigated. The purpose of this study was to examine the effects of using a computer-based practice in a controlled setting on the use of functional communication manifested by children with autism within a natural classroom setting.

METHOD

Participants and Setting

Five children with autism were selected to participate in this study. Children were selected according to the following criteria: formal diagnosis of autism; functional communication, identified mainly by use of delayed echolalia occurring in constructed and nonconstructed activities; possible use of immediate echolalia; possible use of irrelevant speech for functional communication; some use of intentional communication, measured by use of verbal initiation to a communicative partner; normal hearing and vision according to school records; mobility; and regular use of computers in the classroom. All information pertaining to the selection criteria was collected from formal clinical diagnosis and school records and from speech language pathologists and classroom teachers. Acceptance for the study was determined by existence of less than 50% use of functional speech (determined by the number of relevant sentences divided by the total number of sentences produced in a 10-minute interval).

All participants selected for the study were diagnosed with autism and demonstrated delayed echolalia (see Table I). All participants came from Arabic-speaking families and were students in one school for children with autism located in a city in Israel. They ranged in age from 7.8 to 12.5 years and had attended the school from 2 to 5 years. They all demonstrated academic skills (e.g., name identification and ability to name and match colors and objects, build simple puzzles, and sort items).

Edna had immediate and delayed echolalia—she used one- or two-word sentences while echoing the last word in the sentence directed to her. She responded mainly to tangible reinforcements such as food and balloons, talked loudly, and could maintain eye contact. Edna pointed to items when requesting things.

Delia had delayed echolalia and irrelevant speech, but she did not have immediate echolalia. Although she had a large vocabulary, she typically used a limited number of words in answer to specific and direct questions and spoke with a low tone of voice. Her answers were usually in a form of delayed echolalia. She responded to verbal reinforcements and refrained from eye contact. Delia did not use nonverbal communication.

Tom had emotional disturbances in addition to autism, used irrelevant speech, and had immediate and delayed echolalia. Tom's vocabulary was small, and he used it only to initiate during daily routine activities and to answer direct questions. He spoke with a normal tone of voice, maintained good eye contact, and could maintain concentration for 20–25 minutes. Tom did not use nonverbal communication.

Ali used immediate and delayed echolalia and could respond to simple direct questions. He spoke with a low tone of voice and a fast pace, and he maintained good eye contact. He could concentrate for 10–15 minutes and responded well to reinforcements. When he did not get what he wanted, he screamed, cried, and acted in an unexpected manner. Ali also pointed when requesting preferred items.

Sid had moderate mental retardation in addition to autism. He used irrelevant speech and had immediate and delayed echolalia. Sid's vocabulary was good, and he used it to initiate during daily routine activities. Although he could usually answer direct questions, using

Table I. Description of Participants

Name	Age (years)	Gender	Eye contact	Tone of voice	Delayed echolalia	Verbal Abilities: Immediate echolalia	Verbal Abilities: Irrelevant speech	Reinforcement
Delia	12.5	Female	−	Low	+	−	+	Tangible
Edna	11.5	Female	+	Loud	+	+	+	Verbal
Tom	8.0	Male	+	Normal	+	+	+	
Ali	8.5	Male	+	Low	+	+	+	Tangible
Sid	7.8	Male	+	Normal	+	+	+	Verbal

2–4-word sentences, the sentences were not always relevant to the topic. Sid spoke with a normal tone of voice and maintained good eye contact. He could maintain concentration for 15–20 minutes and responded mainly to reinforcements such as music and songs. Sid pointed to items he wanted.

All computer practice sessions occurred at a special location within the school. The student sat at the computer with the investigator sitting by him or her to assist as needed. All data collection sessions were carried out and videotaped within the child's classroom during naturally occurring activities. One investigator videotaped all the sessions.

Materials

A compatible PC loaded with the computer software program developed specifically for the study was used for all practice sessions. The interactive software program (I Can Word It Too) was created especially for the study by the authors with the assistance of a computer programmer. The colorful program is appropriate for use by both genders in two languages (Arabic and Hebrew). I Can Word It Too is a program that contains the three elements of language (i.e., form, use, and content) and the interactions between them (Bloom & Lahey, 1978). Situations that include appropriate statements in a variety of settings were developed using different activities. The situations appear as activities that provide opportunities to use questions and answers formulated by various significant people (e.g., mother and father). Three different settings using situations depicting daily activities were represented in the program (play, food, and hygiene). The settings were taken from the daily routines of these children with autism. They were created to enable children to practice their skills across various familiar activities. Each activity included a small animation related to that activity. All activities depicted familiar activities and used familiar phrases (see Appendix A). The interactive features of the software provided opportunities for children to initiate and respond across the three settings. After an opening statement, the participant was expected to initiate or respond to a question using a variety of possible choices, which were presented as buttons at the bottom of the screen (see Procedures section for a description of the process).

A data collection form was created to obtain the following variables from the videotaped sessions recorded during natural classroom settings: number of sentences using delayed echolalia (i.e., delayed repetition of a sentence or part of a sentence), number of sentences using immediate echolalia (i.e., immediate repetition of the sentence or part of the sentence), number of sentences using irrelevant speech (i.e., the sentence sounds appropriate in its form but has no relevance in the context of the current situation), number of sentences using relevant speech (i.e., the sentence has appropriate form, use, and content, and the interaction is appropriate, too), and number of child initiations (i.e., any verbal communication initiated by the child with a peer or an adult).

Design

A multiple-baseline design across three settings was implemented (Barlow & Hersen, 1984; Kazdin, 1982). Three computer-based training settings (i.e., play, food, and hygiene) were used to investigate transfer to the natural classroom setting. Classroom videotaping during play, food, and hygiene activities continued during the whole study. Baseline data were gathered from the classroom (using the videotapes). Intervention with the first computer setting was implemented after a stable baseline was established. Criterion for transition to the next setting was set for six sessions. Intervention was implemented in the first setting (play), followed by the second setting (food), and ending with the third setting (hygiene).

Procedures

In a city in Israel, a school for children with autism was selected for the study. Based on school records and clinical diagnosis, consent forms were sent to parents of students who met preliminary criteria for the study. After receiving consent forms from parents, observations were made to obtain specific information on the functional communication manifested by the students. Observations were carried out in the natural environments during food, play, and hygiene activities. All activities were videotaped in the classroom, in the natural environment, during regular activities. All communicative behaviors were recorded to obtain additional information needed to finalize the selection process.

During baseline, children were videotaped in the natural classroom settings during their play, food, and hygiene activities for 10 minutes per session, five times a week as part of their regular schedule to prevent any possible bias. All verbal communicative behaviors were recorded including immediate and delayed echolalia, relevant and irrelevant speech, and communicative intentions. All sentences and fragments of sentences

were coded as one of the five variables and summed to indicate the frequency of occurrence during each session. The number of events was recorded in the data collection form. Data were collected every day across all settings for all five students. The videotaping of the regular classroom activities and the recording of all the verbal communicative behaviors continued during baseline and intervention sessions and across all settings. For example, videotaping of food activities occurred during breakfast or snack time, with the teacher sitting by the students, offering them choices and awaiting initiations. Videotaping of play activities occurred while the teacher was interacting individually with the student, using toys and game activities. The hygiene activities were always videotaped after snack while the children washed their teeth, hands, and faces and combed their hair as part of their regular classroom schedule.

Once a clear baseline was established, intervention with the computer software started. Each student was taken separately to a room in the school that was equipped with a PC computer. Intervention began with the first setting. As each session started, the program would open with the first screen depicting a play situation (i.e., the first setting). A recorded voice stated: "With what would you like to play?" The participant could select from three different play situations (i.e., buttons with pictures of the activities on the bottom of the screen) and choose different activities such as playing ball with dad, playing with a teddy bear or a rocking horse, responding to requests to play, and initiating requests for various play activities. The child could select an activity using the cursor. Once selected, a short animation of the chosen activity appeared, followed by a new screen depicting three additional activities and a statement: "Would you like to play some more?" Each situation included part of the activity such as bouncing a ball or rocking the horse as part of the interaction. The activities continued for approximately 10 minutes. During the exposure to the activities, videotaping of the three natural settings in the classroom continued as in the baseline with no interference of the regular classroom schedule.

After six sessions, intervention in the second setting (i.e., food) began. The participant could choose food, respond to requests, and initiate requests for types of food such as cornflakes, bread, or juice, and could then ask for additional or different food items. As in the previous intervention, a screen opened and a recorded voice indicated, "What would you like to eat"? The participant could select a food item from the buttons depicting three food items. Once a selection was made, a short animation appeared followed by a new screen. The second set of activities also lasted six sessions. During this intervention setting, the participant could access both play and food activities.

Once the third setting began, the participant could also access the activities that included opportunities to interact with hygiene. The participant could choose to brush the teeth, wash the hands, or comb the hair. As in the previous activities, each activity included a small animation such as brushing the teeth or washing the face.

Exposure to the program lasted from 10 minutes at the beginning of the first setting to 25 minutes at the end of the third setting (i.e., the exposure time to the software expanded as additional settings were introduced). Each computer session was terminated by the participant or if the participant indicated a desire to quit and return to class. No verbal interaction with the investigator was required during session at the computer. Thus, only nonspecific intermittent comments were provided (i.e., "good work," "keep working"). All intervention sessions (i.e., sessions with the computer) were videotaped.

Interobserver agreement was obtained by having two observers record all verbal communicative behaviors from the videotapes independently for 20% of the data. The observers recorded immediate and delayed echolalia, relevant and irrelevant speech, and communicative intentions from the classroom sessions taken during baseline and intervention sessions. Agreement data were obtained by dividing the number of agreements by the number of agreements and disagreements and multiplying it by 100. Results indicated an agreement of 95% for immediate echolalia, 94% for delayed echolalia, 90% for relevant speech, 94% for irrelevant speech, and 92% for communicative intentions.

RESULTS

Each variable was calculated as the total number of communicative behaviors recorded during each session. Tables II–VI provide the mean and slope for all variables and all participants during baseline and intervention across the three settings. Means were calculated as the summary of all communicative behaviors recorded for each variable divided by the number of sessions before ($n = 30$) and after ($n = 36$) intervention for each participant. These findings indicate a difference attributed to the intervention. Data presented in Figures 1–9 represent the number of sentences used

Table II. Descriptive Statistics for Edna across All Variables and Settings[a]

	Play		Food		Hygiene	
	Mean	Slope	Mean	Slope	Mean	Slope
Delayed echolalia						
Baseline ($n = 30$)	6.50	0.000	5.30	−0.078	2.56	−0.139
Intervention ($n = 36$)	3.88	−0.198	1.58	−0.178	0.50	0.086
Immediate echolalia						
Baseline ($n = 30$)	4.25	0.700	3.20	−0.109	2.13	0.112
Intervention ($n = 36$)	2.39	−0.236	2.00	−0.167	0.33	−0.057
Irrelevant speech						
Baseline ($n = 30$)	3.25	−1.300	1.50	0.139	1.00	−0.124
Intervention ($n = 36$)	0.88	−0.026	1.41	−0.129	0.00	0.000
Relevant speech						
Baseline ($n = 30$)	3.25	−0.300	2.60	0.000	1.18	0.130
Intervention ($n = 36$)	4.83	0.116	3.66	0.140	2.00	0.000
Communication initiations						
Baseline ($n = 30$)	0.00	0.000	0.30	0.006	0.31	0.010
Intervention ($n = 36$)	0.88	0.043	0.75	0.210	0.16	0.286

[a] Total number of sentences used during the 10-minute interval videotaped session.

by the participants during the 10-minute videotaping of the activities in the classroom across the five variables. Figures 1, 2, and 3 present the number of sentences using delayed echolalia for Delia, Tom, and Ali, respectively. Figures 4 and 5 present results for use of immediate echolalia by Edna and Tom, respectively. Figure 6 represents results for irrelevant speech by Ali. Figures 7 and 8 present results for relevant speech by Delia and Tom, respectively, whereas Figure 9 presents results for communicative initiations by Sid across the three situations. Data demonstrate differences for each participant and for each variable across the three settings. Data indicate a clear difference between baseline and intervention across settings, participants, and variables.

The greatest gain for all participants was with sentences involving delayed echolalia. Across all classroom settings, all participants reduced the number of

Table III. Descriptive Statistics for Delia across All Variables and Settings[a]

	Play		Food		Hygiene	
	Mean	Slope	Mean	Slope	Mean	Slope
Delayed echolalia						
Baseline ($n = 30$)	8.25	0.300	5.70	−0.006	2.25	−0.061
Intervention ($n = 36$)	3.50	−0.420	4.00	−0.468	1.50	−0.428
Immediate echolalia						
Baseline ($n = 30$)	0.00	0.000	0.00	0.000	0.00	0.000
Intervention ($n = 36$)	0.00	0.000	0.00	0.000	0.00	0.000
Irrelevant speech						
Baseline ($n = 30$)	6.25	−0.500	5.80	0.084	1.18	−0.008
Intervention ($n = 36$)	3.88	−0.210	2.83	0.006	0.66	0.057
Relevant speech						
Baseline ($n = 30$)	0.50	0.000	1.00	0.000	0.37	0.0117
Intervention ($n = 36$)	4.94	0.203	2.75	0.486	1.66	0.057
Communication initiations						
Baseline ($n = 30$)	0.25	0.100	0.40	0.024	0.31	−0.030
Intervention ($n = 36$)	0.88	0.227	0.66	0.024	0.16	0.086

[a] Total number of sentences used during the 10-minute interval videotaped session.

Table IV. Descriptive Statistics for Tom across All Variables and Settings[a]

	Play		Food		Hygiene	
	Mean	Slope	Mean	Slope	Mean	Slope
Delayed echolalia						
Baseline ($n = 30$)	5.25	−0.300	5.50	−0.006	2.31	0.013
Intervention ($n = 36$)	2.44	−0.270	2.080	−0.255	1.66	0.086
Immediate echolalia						
Baseline ($n = 30$)	1.75	0.300	2.00	0.09	1.81	−0.210
Intervention ($n = 36$)	1.05	−0.044	0.83	−0.08	1.83	−0.714
Irrelevant speech						
Baseline ($n = 30$)	1.25	0.700	0.90	0.248	0.00	0.000
Intervention ($n = 36$)	0.50	−0.070	0.33	−0.020	0.00	0.000
Relevant speech						
Baseline ($n = 30$)	3.00	−0.200	3.70	0.220	0.12	0.023
Intervention ($n = 36$)	7.61	0.060	6.33	0.146	1.16	0.485
Communication initiations						
Baseline ($n = 30$)	0.50	0.200	0.60	0.024	0.06	0.007
Intervention ($n = 36$)	1.00	−0.008	1.41	−0.038	0.33	0.228

[a] Total number of sentences used during the 10-minute interval videotaped session.

sentences spoken with delayed echolalia (i.e., negative slope). An increase in relevant speech was the second most noticeable difference, with the change occurring mostly in food and play activities (i.e., positive slope). The increase was noticeable in slope and in the mean across the three settings for all participants (see Tables II–VI). Changes in all variables were clearly evident during food activities.

During baseline, Edna (see Figs. 2 and 4) used immediate and delayed echolalia as well as irrelevant speech across all activities. Parts of sentences and whole sentences were used. For example, sentences such as "Ball?" or "Teeth?" were used when asked whether she wanted to play ball or brush her teeth. After intervention began, Edna produced fewer echolalic sentences and less irrelevant speech. She initiated more, especially in play activities, and used appropriate speech in all three settings. Table II demonstrates that there were changes in the mean and in the slope across all settings.

Table V. Descriptive Statistics for Ali across All Variables and Settings[a]

	Play		Food		Hygiene	
	Mean	Slope	Mean	Slope	Mean	Slope
Delayed echolalia						
Baseline ($n = 30$)	4.50	−0.400	3.50	−0.066	2.50	−0.002
Intervention ($n = 36$)	2.72	−0.220	0.91	−0.059	1.16	0.028
Immediate echolalia						
Baseline ($n = 30$)	0.25	0.300	1.30	0.078	1.31	−0.089
Intervention ($n = 36$)	0.72	−0.080	0.25	−0.078	2.33	−0.114
Irrelevant speech						
Baseline ($n = 30$)	0.75	0.700	0.60	0.080	0.81	−0.039
Intervention ($n = 36$)	0.16	−0.038	0.08	−0.010	0.16	−0.140
Relevant speech						
Baseline ($n = 30$)	2.00	−0.800	2.70	0.280	0.18	0.0044
Intervention ($n = 36$)	3.83	0.122	3.91	0.087	0.50	0.1428
Communication initiations						
Baseline ($n = 30$)	0.25	0.300	0.60	0.036	0.06	−0.001
Intervention ($n = 36$)	0.61	0.080	1.00	0.097	0.16	0.0857

[a] Total number of sentences used during the 10-minute interval videotaped session.

Table VI. Descriptive Statistics for Sid across All Variables and Settings[a]

	Play		Food		Hygiene	
	Mean	Slope	Mean	Slope	Mean	Slope
Delayed echolalia						
Baseline ($n = 30$)	4.00	0.400	1.80	0.012	1.00	−0.058
Intervention ($n = 36$)	2.38	−0.215	0.33	−0.027	0.16	0.028
Immediate echolalia						
Baseline ($n = 30$)	1.00	−1.000	1.10	−0.066	0.37	−0.047
Intervention ($n = 36$)	0.55	−0.059	0.42	0.080	0.50	0.086
Irrelevant speech						
Baseline ($n = 30$)	1.25	−0.300	2.10	0.006	0.81	−0.110
Intervention ($n = 36$)	0.89	−0.119	1.25	−0.003	0.50	−0.003
Relevant speech						
Baseline ($n = 30$)	5.50	−0.600	2.70	0.430	2.43	0.204
Intervention ($n = 36$)	5.40	−0.047	3.75	−0.059	1.67	0.057
Communication initiations						
Baseline ($n = 30$)	0.75	0.300	0.20	0.002	1.06	0.036
Intervention ($n = 36$)	2.16	0.178	0.25	0.108	1.00	0.400

[a] Total number of sentences used during the 10-minute interval videotaped session.

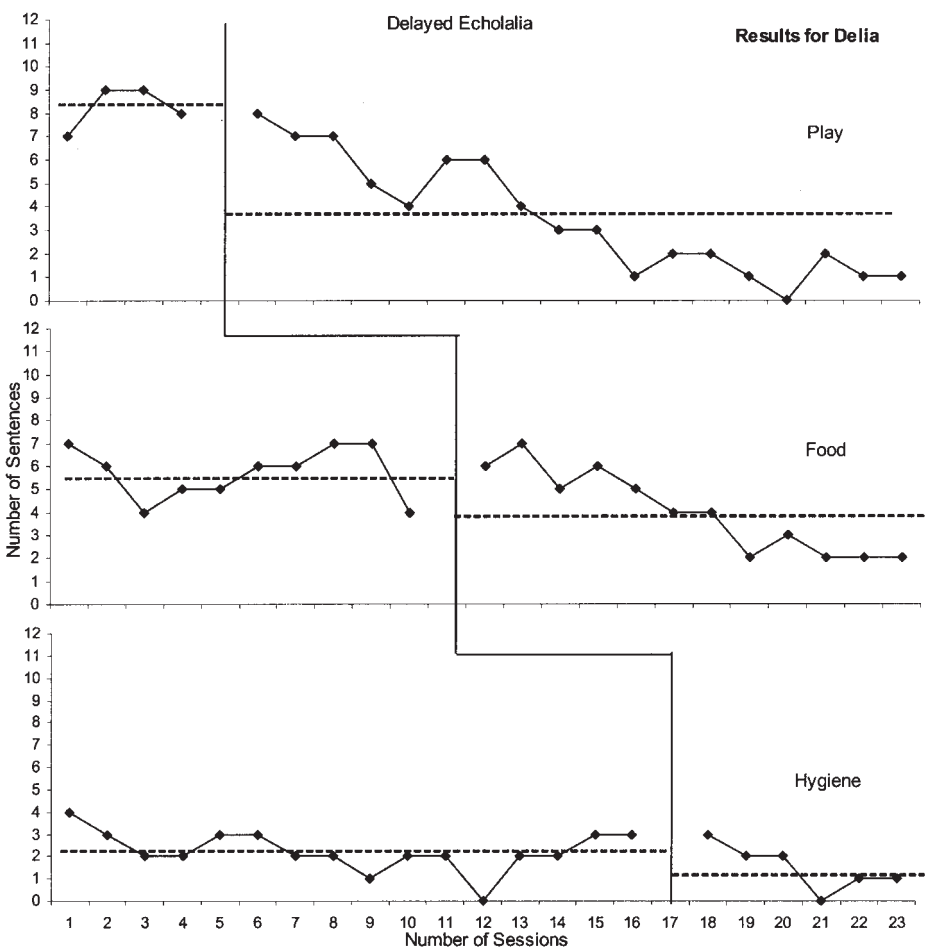

Fig. 1. Number of sentences verbalized by Delia for delayed echolalia across all sessions.

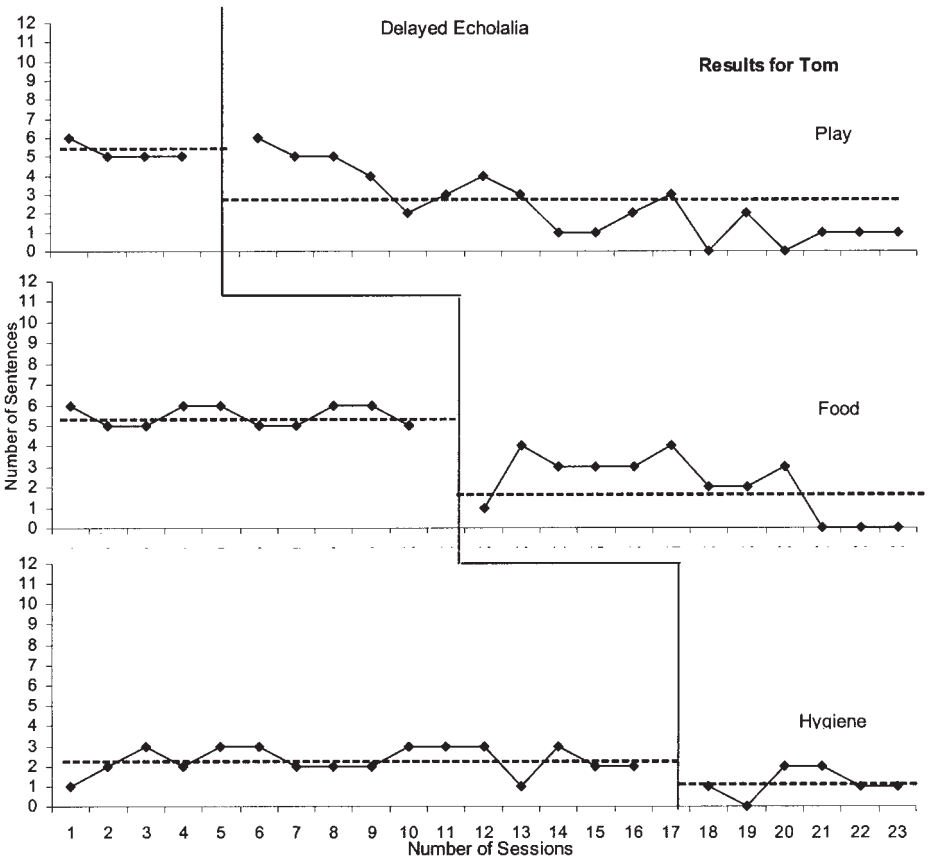

Fig. 2. Number of sentences verbalized by Edna for delayed echolalia across all sessions.

Delia used delayed echolalia and irrelevant speech in all three natural settings during baseline (see Figs. 1 and 7). She produced few appropriate sentences and few initiations. For example, a sentence such as "Mom will wash your hair" appeared during play, or "Dad brought you good stuff" would appear during mealtime. An irrelevant sentence such as "Do you want to swim?" appeared during mealtime. After intervention began, Delia used more appropriate sentences in all three settings, fewer sentences with delayed echolalia, and less irrelevant speech. She initiated more communication in play and food activities, but not in hygiene. Her overall use of appropriate sentences increased across all settings, whereas the use of inappropriate sentences (represented by delayed echolalia and irrelevant speech) decreased across the three settings (see Table III). Delia did not use immediate echolalia before or after intervention.

Tom's delayed and immediate echolalia appeared in all activities during baseline (see Figs. 5 and 8). He did not manifest irrelevant speech often, especially during hygiene activities, and used only a few initiations or attempts to produce appropriate speech. After intervention, Tom's use of immediate and delayed echolalia decreased, especially in play and food activities (see Table IV). Tom increased his use of relevant speech and initiations in all three settings and reduced the number of irrelevant sentences in play activities. For example, he started to ask, "Would you like to play?" or asked for specific games during play activities.

For Ali, a noticeable decrease in delayed echolalia and in irrelevant speech can be detected across all settings (see Figs. 3 and 6). However, Ali's results for immediate echolalia and communicative initiations seem to be mixed, as the most evident change occurring during play activities, and least noticeable change occurring in hygiene activities (see Figs. 3 and 6). Change in the slope is consistent across the variables (see Table V).

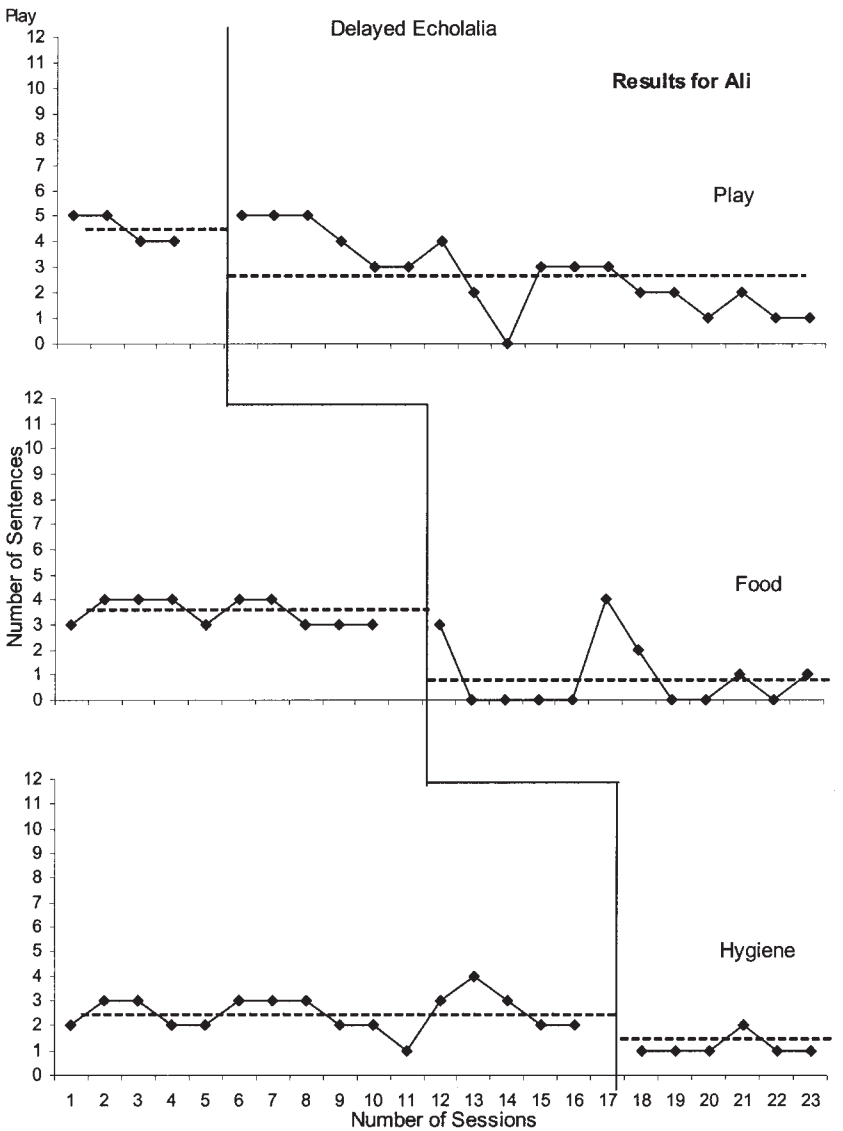

Fig. 3. Number of sentences verbalized by Ali for delayed echolalia across all sessions.

Sid used delayed echolalia, irrelevant speech and some immediate echolalia during baseline. He also used relevant speech before intervention began. Most of Sid's baseline data indicate a use of delayed echolalia as the main form of communication. For example, a sentence such as "With what do you want to play?" or "Spread his sandwich" appeared, as well as segments of sentences such as ". . . play?" After intervention, Sid enhanced his use of appropriate speech and reduced the number of sentences that included delayed and immediate echolalia, but he increased initiations only during play (see Fig. 9). Sid did not demonstrate noticeable changes during hygiene activities (see Table VI).

A paired sample *t* test across means was implemented to compare baseline and intervention for the play, food, and hygiene activities for each of the five variables (see Table VII). A significant difference was found for relevant and irrelevant speech across all settings. Significant differences in the number of sentences involving delayed echolalia and communicative initiations were found across play and food activities.

Although the intervention was effective in improving the communication of all five participants, effects were manifested differently for each. For example, before intervention, Edna frequently engaged in

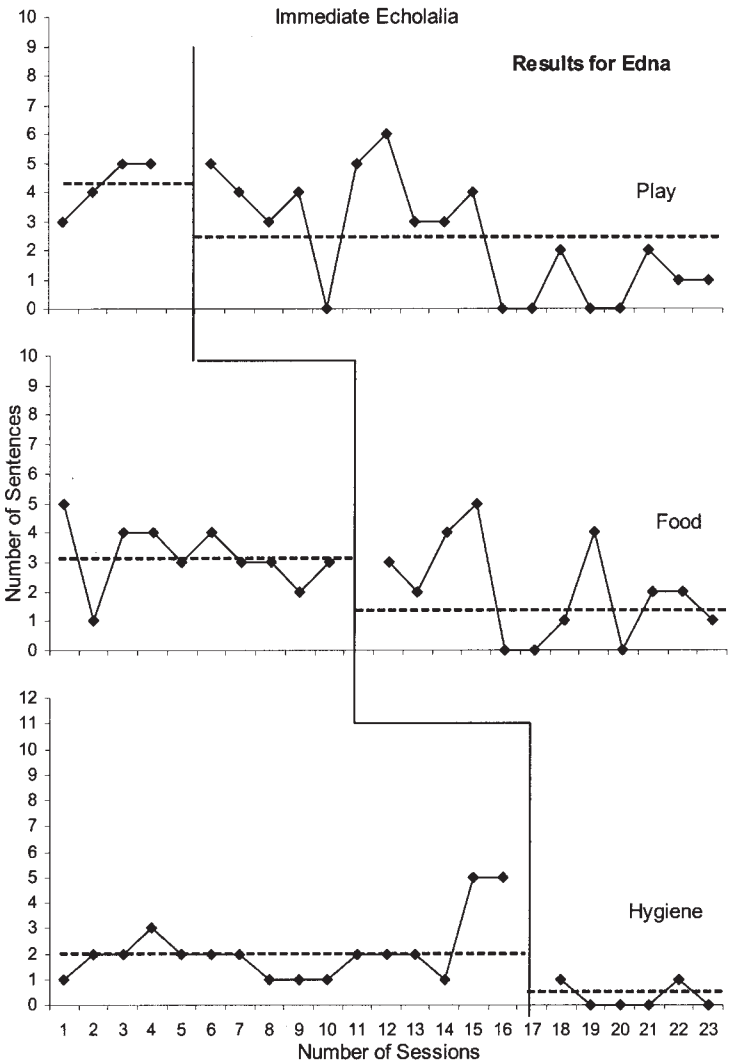

Fig. 4. Number of sentences verbalized by Edna for immediate echolalia across all sessions.

immediate echolalia, repeating the last word or sentence during interactions. After exposure to the program, Edna reduced the number of times she used immediate echolalia, especially in food and hygiene activities, and increased appropriate use of sentences in all activities. For example, if before intervention she used a sentence such as "It is so spicy" while playing, or repeated a sentence such as "With what do you want to play?" she now answered with a short appropriate sentence such as "Ball, goal" or "Want—brush teeth."

Delia used irrelevant speech and delayed echolalia for most of her functional communication. After beginning intervention with the computer program, both these variables decreased, whereas relevant speech and communicative intentions increased. For example, sentences shifted from "Do you want to play ball?" as a request during mealtime, to "I want cornflakes" instead.

Tom incorporated some intentions in his communications even before the intervention, and those initiations increased even more after intervention. Before intervention, he initiated "Wa'na play?" After intervention he expanded those sentences and added words to indicate his exact intentions to include sentences such as "Want to play with the teddy bear?" Tom's use of relevant speech also increased, and improvement started after the second time he worked with the program. Tom increased his communicative initiations especially

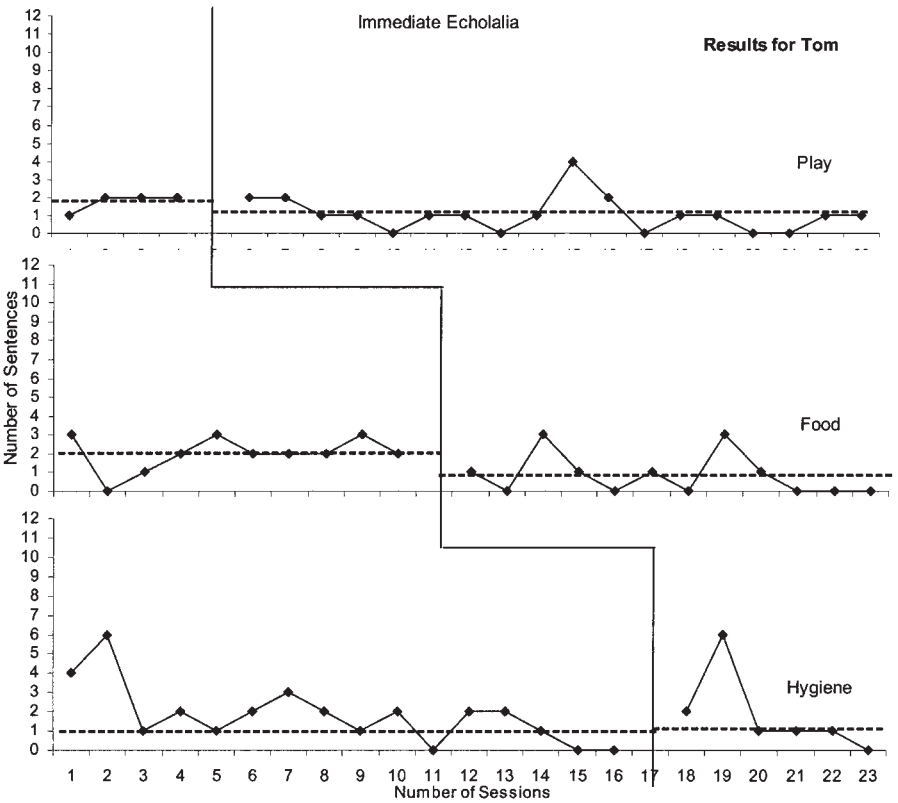

Fig. 5. Number of sentences verbalized by Tom for immediate echolalia across all sessions.

with association to the computer and activities associated with it.

Ali used mainly immediate and delayed echolalia accompanied with crying and hyperactive movements. After intervention, he started to initiate, and many of his echolalic behaviors decreased. His appropriate speech increased especially in food and hygiene activities. In play activities, his behaviors were different. He increased use of communicative initiations but applied them with use of one-word sentences or with echolalic behaviors. Often after receiving a preferred item such as a ball, he answered with an appropriate one- or two-word sentence.

The hygiene activity was not a preferred activity for Sid. He resisted using materials such as soap, water, and toothpaste. Each time those materials appeared, he returned to immediate echolalia. This behavior did not change even after being exposed to the program, although delayed echolalia did seem to lessen during hygiene activities after intervention. During play and food activities, his communicative behaviors changed across variables, mainly demonstrating a decrease in use of immediate and delayed echolalia, which were used frequently before intervention.

DISCUSSION

The purpose of this study was to examine the effects of a computer interactive-intervention program on the communicative functions of children with autism who use delayed echolalia for functional communication. The results provide support for the effectiveness of using a computer-based interactive simulation of daily activities as a vehicle for enhancing appropriate communication. The study indicates that practicing simulated activities on the computer using familiar situations such as play, food, and hygiene enhances use of appropriate functional communication in natural settings.

Communication Behaviors of the Children

The functional communication manifested through five different variables improved for all five participants

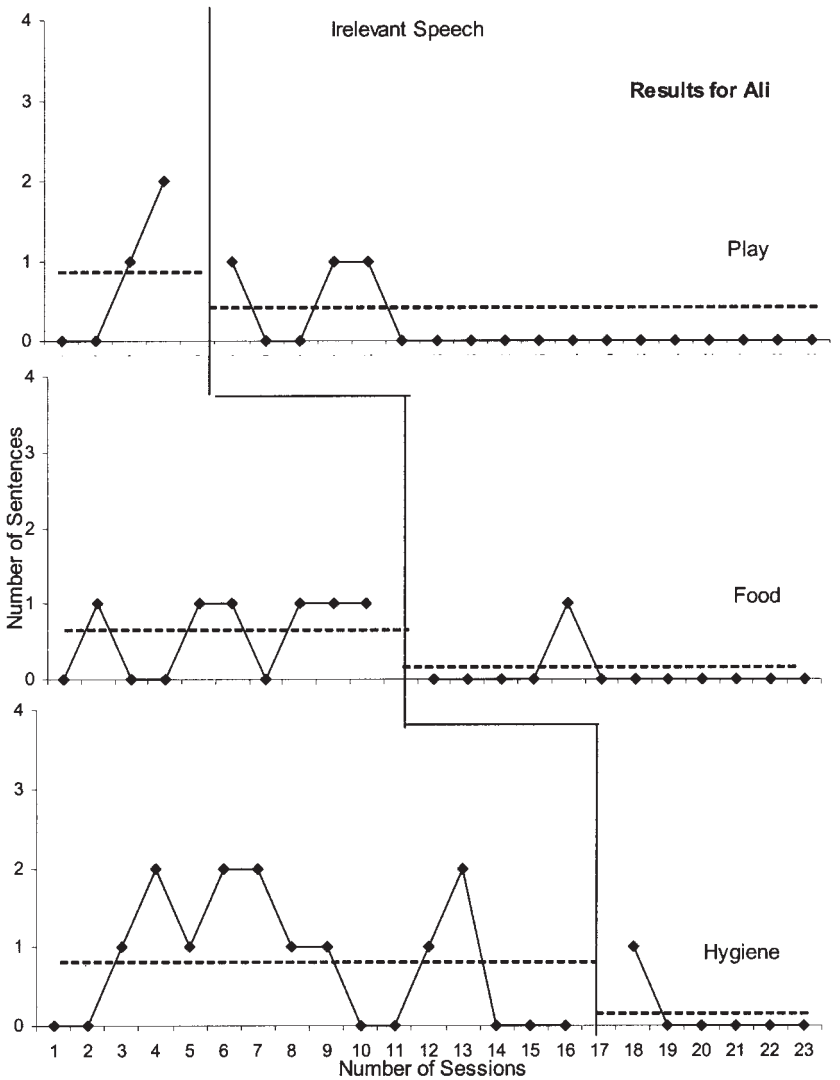

Fig. 6. Number of sentences verbalized by Ali for irrelevant speech across all sessions.

across most of the settings. These findings were significant especially in the decrease of delayed and immediate echolalia and irrelevant speech and in the increase of appropriate speech (across all three settings). For example, before intervention with the computer, Sid would verbalize four or five sentences with delayed echolalia during a 10-minute food activity. Following intervention, the number of inappropriate sentences decreased to about one sentence per 10-minute food activity.

The use of communicative initiations was found to be significantly different for food and play activities, but not for hygiene activities. This could be a result of a general dislike for the particular hygiene activity, which involved soap, water, combing the hair, and physical guidance. In addition, because this activity involved mostly a structured routine, the number of opportunities for participants to initiate, interact, or communicate their wishes was possibly insufficient.

For four of the participants, change in the communicative initiations was noticeable mostly in the change of slope, meaning there was change in the participants' number of initiations over time. As they progressed with the intervention, the participants used more initiations. The exception, Ali, increased his use of communicative initiations, but applied them in

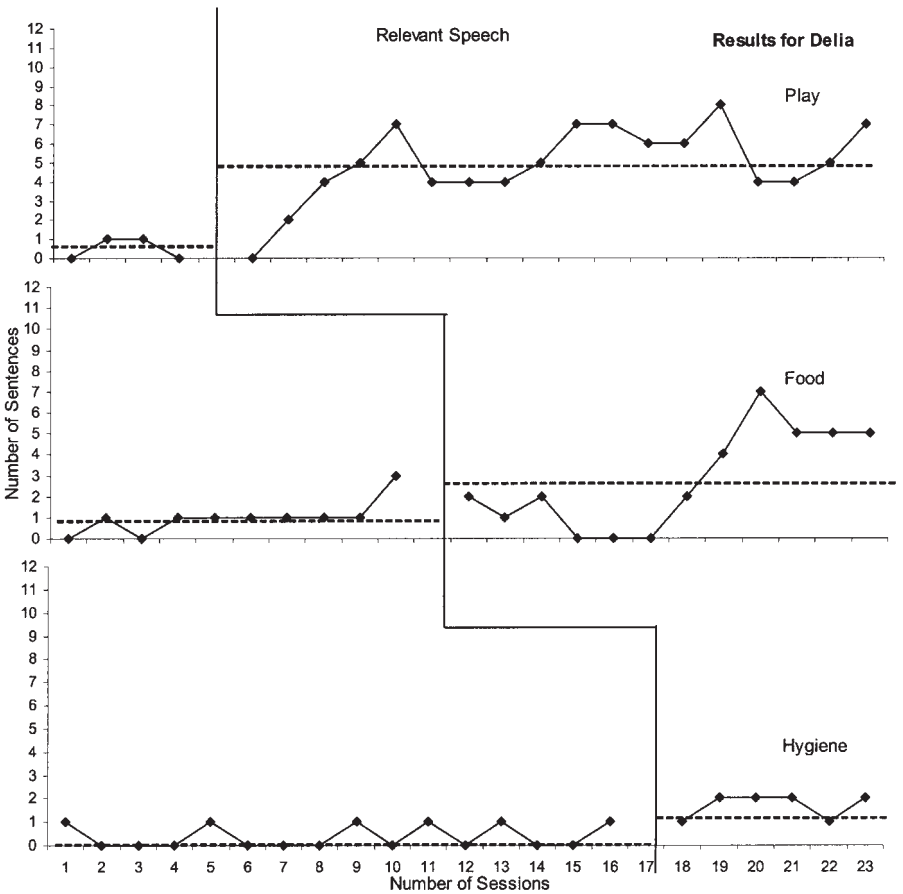

Fig. 7. Number of sentences verbalized by Delia for relevant speech across all sessions.

the use of one-word sentences and with echolalic behaviors, especially after receiving a preferred item. The echolalic behaviors manifested during the play activities could be a result of his hyperactive and unexpected behaviors that seemed to accompany these preferred activities. The reason for this manifestation of such behaviors and this acceleration of the rate of acquisition demonstrated in the changes in slope should be investigated in future research.

The differences in the manifestation of the results, as they appeared for each of the participants, could also be an indication of individual differences. For example, Delia did not use immediate echolalia at all. Edna, who frequently engaged in immediate echolalia, decreased that behavior after intervention in all activities. Delia increased her use of initiations and relevant speech after intervention in play and food activities. However, she did not increase those behaviors during hygiene activities. Sid also disliked hygiene activities and resisted any use of soap, water, toothpaste, or comb in the natural environment within the classroom setting. His use of immediate echolalia increased when those items appeared, regardless of the exposure to the program. Further research could clarify the effect of preferred and nonpreferred activities on the use of inappropriate speech.

The most significant change occurred in the use of delayed echolalia, which is defined as a distorted interaction between form, use, and content (Bloom & Lehey, 1978). Although the participants seemed to have the correct form, it sounded wrong in its interaction with its content and use. The computer program provided the children with opportunities to use the sentences in the correct content, in an appropriate form, and with opportunities to practice in different situations. The participant could initiate or respond with appropriate messages that could have not only reduced the occurrence of delayed echolalia but also

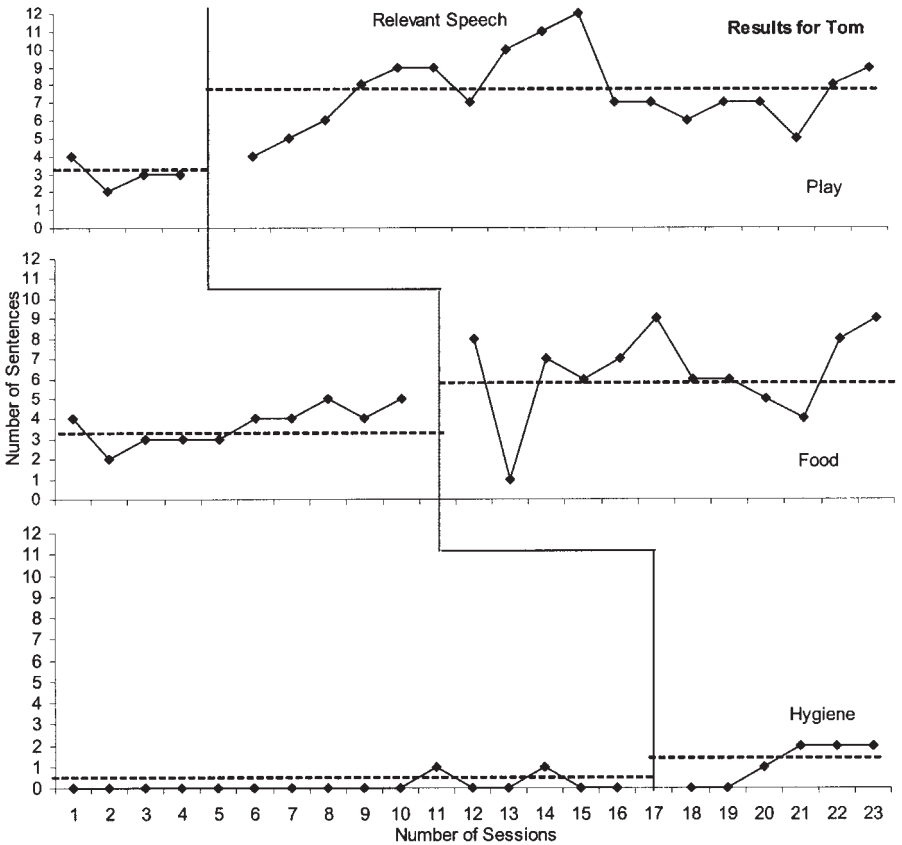

Fig. 8. Number of sentences verbalized by Tom for relevant speech across all sessions.

enhanced the occurrence of appropriate speech. After initiating the intervention, the children transferred the use of appropriate sentences from the simulated environment to the natural environment in the classroom. Although only a limited number of initiations were recorded during the intervention, it is important to note that most of those initiations represent a 50% to 100% increase in a task that is especially difficult for children with autism. These interesting results should be further investigated and expanded to different settings, to different environments, and across time.

Through working with the computer program, all participants improved their functional communication in the food and play activities. All participants were able to generalize and transfer the information gained while practicing the simulated situations in one environment to the natural setting in the classroom. These findings support previous studies that found that practicing in a controlled environment enhanced the performance in a natural setting (e.g., Alcantara, 1994).

Generalization from Structured Simulated Activities to the Natural Setting

Participants were able to transfer the information learned from the structured, simulated, computer-based environment to the natural setting in the classroom. Transition from one environment to another is a task involving an ability to generalize. Generalization, the ability to transfer a learned behavior from a trained situation to another, is considered a difficult task for children with autism (Glennen & DeCoste, 1997; Koegel & Koegel, 1995). Researchers have promoted teaching functional communication in a naturalized setting to ease transition and generalization (e.g., Goosens, Crain, & Elder, 1992; Mirenda, 1997). Results of this study demonstrated that when students with autism were provided with an opportunity to learn and practice meaningful communication in a controlled environment that simulated a naturalized setting, they were able to generalize their knowledge to their classroom.

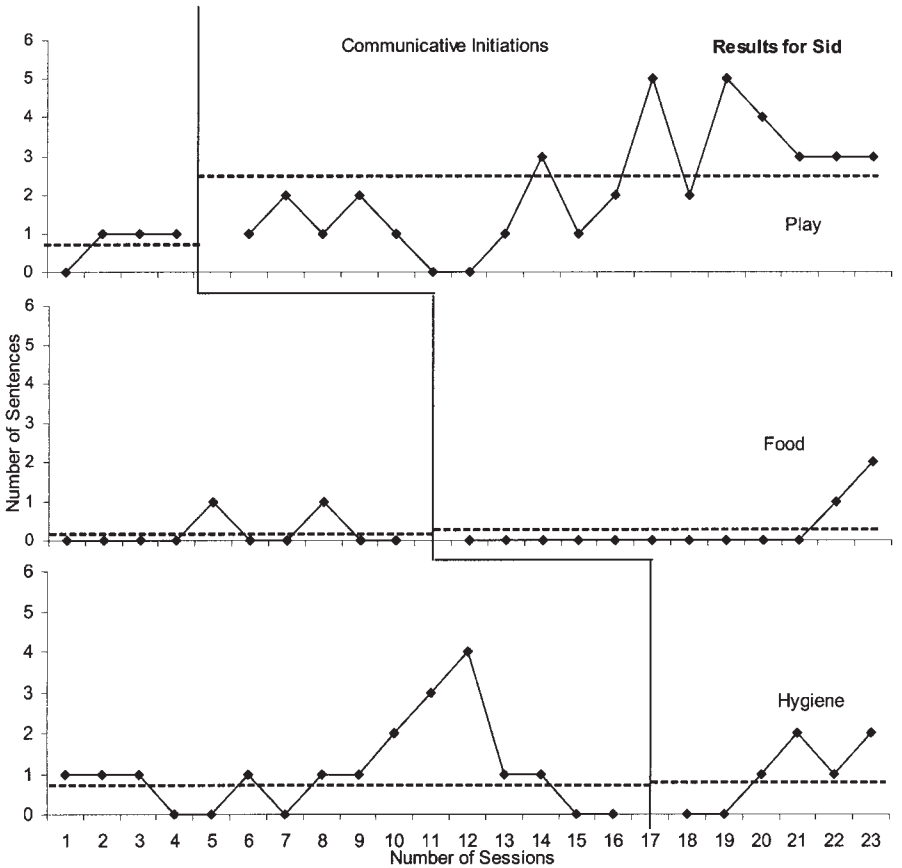

Fig. 9. Number of sentences verbalized by Sid for communicative initiations across all sessions.

Daily use of the program provided the participants with opportunities to practice appropriate functional speech in a controlled environment that presented accurate simulations of their daily activities. This practice provided them with a framework that incorporated questions and answers over which they had control. The questions and answers were designed to provide the participants with opportunities to communicate appropriately in correct form, use, content, and interaction.

One of the most important factors in the success of this study was that all participants preferred the computer interactive program. They always wanted to go to work with the computer, and they participated in the activities until the activities terminated. Some of the students even increased their initiations and use of relevant speech in association with those activities. For example, Tom enjoyed manipulating the software, was excited to go to the computer, and demonstrated communicative initiations associated with these activities. These results concur with previous results on the effectiveness of computer-based intervention for children with autism (e.g., Bernard-Opitz *et al.,* 1990; Chen & Bernard-Opitz, 1993; Panyan, 1984; Yamamoto & Miya, 1999).

The computer program involved activities at different levels of structure. The expectation was that structured activities such as food and hygiene would produce less irrelevant speech and less echolalia (Doss & Reichle, 1991). The structured food activity involved expected routines that resulted in the highest number of changes across variables, especially in immediate and delayed echolalia. The play activity, which was less structured, resulted in less decrease of sentences with echolalia, but an increase in relevant speech and communicative initiations. The hygiene activity, although structured, involved several issues that in effect could have hindered the change in functional communication. The lack of communicative initiations, the limited number of appropriate sentences, and the

Table VII. Statistical Analysis for Each Variable between Baseline and Intervention Data across Play, Food, Hygiene, and All Settings

	Play		Food		Hygiene		All	
	Baseline	Intervention	Baseline	Intervention	Baseline	Intervention	Baseline	Intervention
Delayed echolalia								
Mean	5.70	2.98	4.36	1.78	2.12	0.99	4.06	1.92
SD	1.70**	0.67**	1.67**	1.40**	0.64**	0.64**	2.02**	1.23**
Immediate echolalia								
Mean	1.45	1.24	1.52	0.69	1.12	0.96	1.36	0.96
SD	1.07	1.52	1.18**	0.78**	0.91	0.98	1.22*	1.08*
Irrelevant speech								
Mean	2.55	1.26	2.18	1.18	0.76	0.26	1.83	0.90
SD	2.28*	1.49*	2.10*	1.08*	0.45*	0.3*	1.85**	1.10**
Relevant speech								
Mean	2.85	5.32	2.54	4.08	0.85	1.39	2.64	4.49
SD	1.83*	1.40*	0.97**	1.33**	0.97	0.58	1.23**	1.39**
Communicative initiations								
Mean	0.35	1.10	0.42	0.81	0.36	0.36	0.37	0.76
SD	0.28**	0.60**	0.17*	0.42*	0.41	0.36	0.28**	0.54**

* $p < .05$.
** $p < .01$.

limited decrease in the appearance of immediate and delayed echolalia could be a result of other factors influencing the communication. As mentioned, those could be a result of one of several issues: a sensitivity to actually touching detergents, a general dislike of the activity, or some other, unknown factor. These issues should be further investigated to enhance the understanding of the influence of factors involving hygiene activities on the communication of children with autism.

Several prior studies have used computers to enhance educational and social activities of children who have autism. However, the use of a computer program to investigate the pragmatics of communication and language use by children with autism was not previously addressed. Providing children with opportunities to practice pragmatics in a controlled, structured, and familiar context through computer simulation improved their communicative functions and decreased the impairment manifested in the inappropriate language use, form, and content and the interaction between them. Transition from a simulated situation and generalization of the behaviors to the natural classroom environment was also successful for those children. ToM may still be impaired for the participants even after exposure to the program. However, through daily use of appropriate speech under the controlled environment, they learned to produce appropriate speech and decrease the number of inappropriate sentences across most of the situations.

The simulated computer program appears to be a promising strategy for teaching pragmatics and generalizing it to natural settings. Future research could also investigate the generalization from computer-based programs that explore situations in the classroom, at home, and in the community. The use of such programs and the development of additional programs could enhance our knowledge of instructional strategies for enhancing communication of children with autism. Additional computer-based programs that enhance the communication of children with autism who have other linguistic impairments, such as children who have a disorder of form or a disorder of use, could also enhance our understanding and provide additional opportunities to expand on the understanding of ToM and impairments of communicative functions. With the knowledge gained regarding the enhancement of functional communication and appropriate speech in the classroom, using computers for practice, future research could investigate the potential gains to communication initiations using prompts for generalization within the natural settings.

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APPENDIX A

Sample of a Translation of the Dialogue Presented in the Computer Program

Activity	Computer	Participant's selections	Result of action
Play	Father: With what would you like to play?	I want to ride the rocking horse	Animation of child rocking horse and saying "Look at me"
		I want to play with the teddy bear	Animation of child playing with the bear and saying "This is fun"
		I want to play ball with you	Animation of child playing ball with dad and saying "Catch the ball"
	Father: Would you like to play more?	I want to play with the rocking horse	Animation
		I want to play with the teddy bear	Animation
		I want to play ball with Dad	Animation
Food	Mother: What would you like to eat?	I want to eat bread with cheese	Animation of child eating and saying "This is tasty"
		I want to drink chocolate milk	Animation of child drinking and saying "This is good"
		I want to eat snack	Animation of child eating and saying "I like it"
	Mother: Would you like to eat more?	I want to eat bread with cheese	Animation
		I want to drink chocolate milk	Animation
		I want to eat snack	Animation
Hygiene	Mother: What would you like choose?	I want to brush my hair	Animation of child brushing hair and saying "Look at me"
		I want to wash my hands with soap	Animation of child washing hands under tap and saying "This is fun"
		I want to brush my teeth	Animation brushing teeth and saying "This is clean"
	Mother: Would you like to choose again?	I want to brush my hair	Animation
		I want to wash my hands with soap	Animation
		I want to brush my teeth	Animation

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