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Increasing Reading and Communication Skills in Children with Autism Through an Interactive Multimedia Computer Program[1]

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This paper reports on the effect of using an interactive and child-initiated microcomputer program (Alpha) when teaching three groups of children (N = 30) reading and communications skills: (a) 11 children with autism (M chronological age, CA = 9:4 years), (b) 9 children with mixed handicaps (M CA = 13:1), and (c) 10 normal preschool children (M CA = 6:4 years). Their mental age varied from 5:8 years to 6:9 years and all children received computer instruction supplementary to their regular reading and writing

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activities. Tests of reading and phonological development were carried out at the onset of the training (Start), at the end (Post 1), and at a follow-up evaluation (Post 2). In addition, video observations of the childrens' verbal and nonverbal communication were added at Start and Post 1. The children with autism increased both their word reading and their phonological awareness through the use of the Alpha program. Clearly significant gains were observed during the intervention, but none during the follow-up period. A similar but weaker pattern is observed for the children with mixed handicaps. In contrast, the normal preschool children increased their scores regardless of the program. Analyses of the children's classroom behavior indicate that the intervention succeeded in stimulating verbal expressions among the children with autism and mixed handicap. A significant increase in enjoyment was also noted for the children with autism. It is concluded that the intervention with a motivating multimedia program might stimulate reading and communication in children with various developmental disabilities, but that such interventions must be individually based and include both detailed planning and monitoring from teachers, and parents, as well as from clinicians in charge.

One of the earliest attempts to use a computer to stimulate language development in children with autism was described by Colby (1973). The program he used allowed the child to press a letter on the computer and simultaneously hear the computer say the letter. In another game, the child pressed a letter (e.g., "H") and then saw a horse moving across the screen together with sound from the horse's hoofs. The aim of this early multimedia attempt was to mimic normal spontaneous language acquisition and to encourage free exploration of the computer material. Colby reported on the results from 17 mute children with autism and claimed that 13 of these showed positive gains. That is, they started to use some voluntary speech and often also displayed enjoyment and motivational gains. However, no details were presented as to how many sessions were used, how long the intervention continued, and how the children were diagnosed.

About a decade after Colby's report, Panyan (1984) published a review on the use of computers with children with autism. He noted that the computer technology offers greater possibilities for enhancing both interaction and attention, but that few systematic studies had been reported thus far. According to Panyan, computers could be used to address several areas relevant for people with autism, as for example: stimulus overselectivity, motivational support, and for improving interaction.

Today, more than 10 years after Panyan's review, we still lack good systematic observations on the effect of computers for stimulating learning and/or communication among children with autism. One of the few findings reported in the literature has been provided by Jordan and Powell (1990a, 1990b) who reported positive effects of an intervention program that focuses on enhancing different cognitive skills (e.g., problem-solving strategies) among children with autism: The British children that used their program displayed positive gains as measured by cognitive tests. However, they also stated that children with autism need to be encouraged (not directed) in order to keep attention, and that the tasks must be "seen as solvable by the child" (Jordan & Powell, 1990a, p. 22).

Positive effects are also reported by Bernared-Optiz, Ross, and Tuttas (1990) who used computer-aided instructions (CAI) with autistic subjects to facilitate learning in school settings both in Germany and Singapore. One of their studies compared the effectiveness of computer-aided learning with more traditional learning relying on personal instruction. Of 18 observed children and adults with autism (ages 5–31), 6 were rated higher when learning through CAI while only 1 was rated highest when personal instruction was used. Furthermore, they also described how CAI could help a 17-year-old boy to use less echolalia and how a 16-year-old boy with poor writing skills managed to increase his skills substantially through a computer intervention.

A third attempt to use CAI with children with autism has been presented by Coldwell (1991a, 1991b), an Australian researcher who has studied computers as a means of communication for mute autistic children. The hypothesis behind this attempt is that mute children with autism develop their own graphic symbols that are understandable to themselves and often also other children with autism, but not to nonautistic subjects. In one of his studies, Coldwell reported on eight children with autism in the age range 3–12 years (2 girls, 6 boys) who worked with the computer together with their parent with the aim to use graphics and to create symbols of various kinds. According to Coldwell, several subjects displayed concentration and responses that went far beyond what was expected based on former performance and he claims—or hopes—that, in the future, people with autism might be helped through computer networks and data banks to communicate with each other through a graphic communication system specially developed by and for them.

Although Coldwell's expectations might be judged as both too speculative and too provocative, the attempt to use CAI to support language and communication growth for disabled children is still a hopeful avenue for present and future educational attempts. We know that it is absolutely essential for a child's future functioning that the child has been given adequate possibilities to develop his or her language skills as far as is possible. This holds true not only for children with developmental disabilities like autism

(Howlin & Rutter, 1987; Schopler & Mesibov, 1985), but also for children with special needs (e.g., Baldrey, 1991; Douglas, 1991; Hasselbring, 1984; Semmel, Cosden, Semmeh, & Keleman, 1984) and normal children (e.g., Nelson, 1977). It seems therefore extremely important to increase our tools for helping children develop language skills. To date, several studies report on the positive use of computers for children with various developmental disabilities (e.g., Green & Clark, 1991; Light, 1988; Nelson, Prinz, Prinz, & Dalke, 1991; Romski & Sevcik, 1989; Underwood & Underwood, 1990), but solid data on the effectiveness of computers for children with autism are still lacking. Very few studies have presented observations from well-designed experiments or quasi-experiments and several of the reports also failed to report enough details as to how the actual training was carried out.

Finally, there is also a need to address the issue of individual strategies when learning language. Normal children use different strategies when learning their native language (Bates, 1979; Nelson, 1991, Nelson, Baker, Denninger, Bonvillian, & Kaplan, 1985) and this is probably also the case for children with autism as well as for children with other types of developmental disabilities (Howlin, 1989; Iacono, 1992; McTear & Conti-Ramsden, 1992). Furthermore, Romanczyk, Ekdahl, and Lockshin (1992) reported that they often have observed that even those children with autism that have explicitly expressed their preference for the computer tend to actually perform better with the teacher. Thus, we should not expect that CAI and related interventions will solve all the problems for children with autism. Rather, it is our view that computer-aided interventions might be of *some* help to *some* children with this diagnosis.

This paper presents observations and results from a quasi-experimental field study aimed at investigating the effects of CAI that included a highly motivating and interactive multimedia environment when teaching children with autism reading and writing skills. A Swedish version of Alpha (Alpha Interactive Language Series/Gator Super Sentences; Nelson & Prinz, 1991) was used for teaching reading and communication skills to (a) children with autism, (b) children with various degrees of cerebral palsy and/or mental retardation, and (c) a group of normal preschool children. The program uses on-screen animations as well as videodisc material that gives the child an immediate feedback. Each noun or verb is immediately animated during sentence creation, and after completion the whole sentence is shown in text and as an animation. In addition, the teacher promotes a warm and supporting atmosphere and uses recasts, questions, and elaborations that tie in with the child's verbal activity and thus promotes a learning environment that maximizes the likelihood for the child to learn new language structures (see Nelson, 1991).

Hypotheses

Previous research with the Alpha program reports positive effects on the reading and language development for children with severe hearing impairments (Prinz & Nelson, 1985; Prinz, Pemberton, & Nelson, 1985), children with multihandicaps, normal preliterate children (Nelson, Loncke, & Camarata, 1993), and also for a subgroup within the current project (Heimann, Nelson, et al., 1993a, 1993b). Despite the obvious differences between these groups, under conditions of CAI support for appropriately challenging lessons they all show a pattern of significant gains in reading skills. Thus, we developed specific hypotheses regarding (a) the children's reading development, (b) the children's verbal expressiveness while interacting with the teacher, and (c) the children's motivation for communication. Furthermore, we also predicted positive changes within two areas of communicative development that could be facilitated by high attention to the computer material in conjunction with the teacher's active dialogue with the child: Phonological awareness and overall verbal level as measured by a sentence imitation test. Positive changes were expected within all these areas as an effect of the CAI as implemented with teachers as active partners.

METHOD

Subjects

A total of 30 children divided into three groups participated in the study.

Children with Autism. Group A children were 9 boys and 2 girls diagnosed according to the DSM-III-R (American Psychiatric Association, 1987) as suffering from autistic disorders, and with a chronological age between 6:9 and 13:8 years (*M* age = 9:4; see Table I). Nine of the children were diagnosed at the Child Neuropsychiatric Clinic, Göteborg (Head: C.G.) and two at a regional hospital (Lidköping, Sweden). Mental age varied between 3:0 and 9:5 years (Coloured Progressive Matrices, a test of nonverbal intelligence; Raven, Court, & Raven, 1984) and receptive language age between 2:9 and 7:0 years (estimated by an adaptation into Swedish of the Norwegian version of the Reynell Developmental Language Scales; Reynell, 1977; Hagtvet & Lilliestølen, 1984). All children attended school clinics specialized for teaching children with autism and all children were judged by their teacher to have displayed some basic communicative motivation.

Table I. Mental Age (MA), Chronological Age (CA) and Language Age (LA) for the Participating Children[a]

		MA		CA		LA	
Groups	*n*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Combined (A + MH)	20	6:3	1:8	11:4	4:6	4:7	1:6
Autism (A)	11	6:9	2:1	9:4	2:4	4:9	1:10
Mixed handicap (MH)	0	5:8	0:5	13:1	5:6	4:1	1:3
Normal preschool	10	6:3	1:2	6:4	0:8	6:10	0:3

[a] Age given in years:months.

Children with Mixed Handicaps. Group MH comprised 9 children (4 boys) with a mean chronological age of 13:1 years (*SD* = 5:6). Their estimated mental age ranged from 5:0 to 6:6 years (see Table I) and the observed receptive language age ranged from 2:8–7:0. All were judged to have an IQ score of 70 or less. Seven of the children had at least one motor or sensory impairment and 2 of the children (2 boys) had received the diagnosis Down syndrome.

Normal Preschool Children. Group NP consisted of 10 normal preschool children (2 boys) enrolled in a normal day-care institution. Their mean chronological age was 6:4 years and their mean mental age 6:3 years. Their language development ranged from a language age of 6:3 to 7:0 years.

Procedure

All children used a Swedish version of Alpha and received a number of 19.3 training sessions (*SD* = 11.9) during 3 to 4 months (*M* = 13.6 weeks, *SD* = 8.3). More specifically, Group A received on average 25.6 sessions (*SD* = 7.5) over 16.9 weeks (*SD* = 5.7); group MH, 21.8 sessions (*SD* = 12.7) over 17.7 weeks (*SD* = 10.1); and Group NP, 7.8 sessions (*SD* = 7.3) over 6.3 weeks (*SD* = 2.5). The training was carried out weekly (*M* = 1.5 sessions per week; *SD* = 0.9) and each session lasted between 21.1 (*SD* = 5.0; Group MH) and 32.0 minutes (*SD* = 12.6; Group A).

All children were given a familiarization period with the Alpha program prior to the actual training. The purpose of this period was (a) to see if the children were as motivated and as interested as had been indicated by their teacher and/or patents, (b) to allow all children to learn the basic set-up and functions of the program, and (c) to find out the right level to start from. The number of familiarization sessions were 5.9

(SD = 3.3) for Group A, 13.0 (SD = 7.9) for Group MH, and 3.2 (SD = 2.4) for Group NP.

The children were tested at three occasions and observed (videorcorded) twice. The first test was carried out after the end of the familiarization period (Start test), the second test (Post 1) during the last week of training, and the follow-up assessment (Post 2) approximately one semester (M = 26.2 weeks, SD = 14.8) after Post 1. Two of the children in the normal preschool group did enter school during their follow-up period.

Program Description

The Alpha program (Nelson & Prinz, 1991) is constructed to facilitate language learning through multichannel feedback (voice, animation, video, and sign language). For this study, sign language was not used and Alpha was translated to Swedish using the words and animations already incorporated in the United States version. Thus, no attempt was made to change the program towards how familiar or difficult the words were to a Swedish child learning to read her or his native language. The Swedish Alpha consists of 112 lessons, all aimed towards developing a basic reading and writing vocabulary, and the ability to create simple sentences using this vocabulary. The program makes it possible to select one of four main working modes: Individual Words (IW), Creating Sentences (CS), Testing Words (TW), and Testing Sentences (TS). Initially all children started with the IW mode in order to learn the vocabulary (= nouns) of a particular lesson. When the child mastered the lesson, as indicated by the test score (TW), the child moved on to the CS mode. Within this mode a child could create sentences by combining earlier learned nouns with new verbs. That is, selection of a simple noun–verb–noun sequence like "The bear"–"jumps over"–"the horse" creates an animation showing the action the child has described. Feedback is also provided during sentence construction. Each noun is illustrated by an appropriate animation while each verb is illustrated by two different animations illustrating the same action. Those children using a system version that included a videodisc player (see Equipment, below) saw the nouns and the verbs illustrated by short video examples instead. After having explored a lesson in the CS mode twice (or earlier if it was obvious that the child had mastered the level) the teacher switched to the TS mode for that lesson. In this mode, the program produced an animated depiction of a noun–verb–noun sequence randomly generated from the vocabulary used in the lesson. After having watched the animation, the child had to select the nouns and the verb to construct the sequence that described what the child had just seen. At any given level, a child was judged to have reached mastery if reaching a score of or above 80% correct in the TS mode.

Measures

Several tests were used to assess each child's language and communication skills before and after the training period:

Reading. Three different tests were used in combination order to measure progress in reading: Flashcard A or B (sentences), Flashcard C (words), and Umesol (letter identification and word reading). Flashcards A, B, and C were all developed within the project while Umesol (Taube, Tornéus, & Lundberg, 1984) is a well-known test in Sweden. The reading score used in the analysis is based on a combined score from all three tests.

Sentence Imitation. This test, based on previous research with the Alpha program (Prinz et al. (1985), measures the child's ability to imitate in his or her best communicative mode (i.e., spoken language, Swedish Sign Language, or BLISS symbols). It includes items of increasing length and grammatical complexity.

Phonological Awareness. The children's phonological awareness (sound synthesis) was assessed using a Swedish instrument (Tornéus, Taube, & Lundberg, 1984).

Communication. Video recordings of each child's communicative behavior during one initial and one final lesson were analyzed using five different categories: Complies, Off Task, Seeks Help, Verbal Expressions, and Enjoyment (a complete description of the coding criteria and procedure can be obtained from the first author). A total of 9 minutes, divided into three periods (first, middle, and last 3 minutes of the session), were coded for each lesson and the occurrence of each category during every 10-second interval was noted by the coder. One of the authors (T.T.) coded all observations (a total of 38 lessons for groups A and MH) and reliability was checked by having a graduate student code 10% of the material (randomly selected). The obtained overall reliability coefficient was .86 for Pearson's *r*, and .81 for kappa (Cohen, 1960).

Level of Autism. The level of autistic features/behaviors among the children diagnosed as autistic (Group A) and the children with mixed handicaps (Group MH) was estimated by completing the Childhood Autism Rating Scale (CARS; Schopler, Reichler, & Renner, 1988). All children in both groups were rated from videotape and through interviews with the child's teacher by a psychologist who had not been part of the original study and who was also uniformed as to what group the children belonged. It was found that the average scores for Group A ($M = 41.9$; $SD = 12.7$) and Group MH ($M = 26.1$; $SD = 4.4$) differed significantly, $t(18) = 3.55$, $p < .01$.

Equipment

Each child worked with either an Apple IIe or Apple IIGS microcomputer system with a minimum of 12 8 K RAM and a printer. In addition, all children in the comparison group and seven of the children with autism had access to a Sony videodisc player (LDPl-3600D).

Subject Loss

Children with Autism. Group A originally consisted of 12 children, but 1 child never completed the training period due to problems in arranging an acceptable educational environment. In addition, 2 more children were dropped during the familiarization period; they were not attracted by the computer and they also displayed a wide variety of severe stereotypical and uncontrolled destructive behavior.

Children with Mixed Handicaps. Group MH: One girl left the study after only a couple of weeks of training. She was motivated by the program but became so frustrated by her slow progress that her teacher and her parents decided not to continue.

Normal Preschool Children. Group NP: One additional child started the training, but never had the chance to continue for an acceptable length of time due to her family leaving for an early summer vacation.

Data Loss

Not all children in each group were successfully tested on all tests. For Group A the actual number of children included varied from 7 (sentence imitation) to 11 (coding of communication) while for Group MH the variation was between 5 (sentence imitation) and 9 (coding of communication). For Group NP, several children were lost after completion of the training, thus making it impossible to carry out any follow-up test. As an example, successful video observations could be carried out for only 3 children in Group NP when ending their training. This large and unexpected loss of data was due to administrative and political reasons: The city council of Göteborg drastically implemented strong cutbacks severely affecting the participating day-care center.

Statistical Analysis

The analysis focuses on changes over time in observed means within each group/subgroup. Since both parametric (paired t test) and nonparametric methods (Wilcoxon) reveal similar results only the t statistics are reported in the present paper. Furthermore, a one-tailed significance level

Table II. Number of Alpha Lessons Covered from Start to Posttest 1 (Max = 112)

	Alpha lesson number				Comparison	
	Start test		Posttest 1			
	M	*SD*	*M*	*SD*	*df*	*t*
Combined (A + MH)	6.1	6.9	21.1	12.1	17	5.4[b]
Autism (A)	4.9	6.7	22.2	15.6	8	3.5[a]
Mixed handicap (MH)	7.3	7.2	19.9	8.2	8	5.3[a]
Normal preschool	2.6	1.9	21.5	11.2	7	4.7[a]

[a] $p < .01$.
[b] $p < .0001$.

is accepted throughout since each of the results refers to one of our specific hypotheses. No systematic between-groups comparison has been carried out due to small *N*s and to fewer lessons given to the normal preschool children as compared with the children with autism and mixed handicaps.

RESULTS

The Alpha Program

All three groups of children made considerable and significant progress within the Alpha program from the onset (Start) to the end of the training (Post 1). As presented in Table II, the children with autism progressed from Alpha Lesson 5 ($M = 4.9$, *SD* 6.7) to Lesson 22 ($M = 22.2$, $SD = 15.6$) while the children with mixed handicaps on average went from Lesson 7 ($M = 7.3$, $SD = 7.2$) to Lesson 19 ($M = 19.9$, $SD = 8.2$). The normal preschool children showed a similar pattern despite the fact that they received a shorter intervention period: They progressed from Lesson 3 ($M = 2.6$, $SD = 1.9$) to Lesson 22 ($M = 21.5$, $SD = 11.2$). Furthermore, the total number of lessons that the children received, that is the sum of both the initial familiarization period and the subsequent intervention period, varied narrowly from a mean of 20.0 ($SD = 8.2$) for Group MH to 21.4 ($SD = 11.7$) for Group A, and a mean of 26.1 ($SD = 11.4$) Alpha lessons for Group NP. A post-hoc comparison between the three groups using Student's *t* test showed a nonsignificant result ($p > .10$). Thus, the three groups seem to have received very similar amounts of training as indicated by the number of lessons covered within the Alpha program.

The children's performance on Alpha's built-in test modes (Testing Words and Sentence Testing) indicate that all three groups did learn both words and sentences through the program. The actual performance on the final sentence test show that the children with autism received a score of 92% correct (SD = 8.4), the children with mixed handicaps scored 80.9%

($SD = 11.1$), and the normal preschool children 97.9% correct ($SD = 6.0$). Thus, the children in all three groups had learned to master new language material during their training with Alpha.

Reading

A clearly significant change, $t(15) = 2.88$, $p < .01$, is noted for the combined results for the children with autism (Group A) and the children with mixed handicaps (Groups MH) during the training period with Alpha (from Start to Post 1; Table III). Stated more specifically, the children with autism increased their mean scores from .03 to .14, $t(8) = 2.85$, $p < .05$; the children with mixed handicaps from .18 to .23, $t(7) = 1.79$, $p < .06$; and the normal preschool children displayed a gain of .16, $t(9) = 2.11$, $p < .05$. The children in Group A also displayed a significant change from Start to the follow-up evaluation (Post 2), $t(8) = 2.85$, $p < .01$, but no significant change is noted for the follow-up period per se. The children in Group MH displayed no significant changes when their result at follow-up (Post 2) is analyzed although a clear change in the observed means can be noted.

In contrast to the other two groups, a significant change is noted for the normal preschool children during the follow-up period between Post 1 and Post 2 without Alpha teaching. This indicates that the Alpha program had a specific effect on the reading development for the children in Group A and Group MH while the children in Group NP showed a less specific response to the intervention. However, it ought to be noted that the changes in observed means, specifically for Group MH, also indicate strong individual variation among the observed results for the children.

Phonological Awareness

Overall, all children increased their means during the training period (Start–Post 1) which is evident by the combined result for Group A and Group MH displayed in Table IV. Significant gains are observed both during the training period proper, $t(13) = 2.7$, $p < .02$, and from Start until Post 2 at the follow-up evaluation, $t(13) = 1.99$, $p < .05$. If each group is analyzed separately, we note significant gains for both Groups A and NP from Start to Post 1 (see Table IV), $t(7) = 2.5$ and $t(8) = 2.48$, respectively, $p < .03$), and for Group MH from Start to Post 2, $t(5) = 2.29$, $p < .05$. In contrast with the results for the children with autism and the

Table III. Start and Posttest Results for Composite Reading Scores Based on Three Reading Tests

		A		B		C		t-Test comparison		
		Start		Post 1		Post 2		($p <$)		
Groups	n	M	SD	M	SD	M	SD	A–B	A–C	B–C
Combined (A + MH)	17	.11	.3	.19	.3	.25	.3	.01	.01	—
Autism (A)	9	.03	.1	.14	.2	.19	.2	.05	.01	—
Mixed handicap (MH)	8	.18	.3	.23	.4	.29	.4	.06	—	—
Normal preschool (NP)	10	.18	.3	.34	.4	.54[a]	.4	.05	.01	.01

[a] $n = 6$ at Posttest 2 for the comparison group.

Table IV. Start and Posttest Results for Phonological Awareness

		A		B		C		t-Test comparison		
		Start		Post 1		Post 2		($p <$)		
Groups	n	M	SD	M	SD	M	SD	A–B	A–C	B–C
Combined (A + MH)	14	.18	.3	.32	.4	.36	.4	.05	.05	—
Autism (A)	8	.19	.3	.35	.4	.24	.3	.05	—	—
Mixed handicap (MH)	6	.17	.4	.27	.4	.48	.4	—	.05	—
Normal preschool (NP)	9	.58	.3	.73	.3	.98[a]	.1	.05	.05	.05

[a] $n = 7$ at Posttest 2 for the comparison group.

Table V. Start and Posttest Results for Sentence Imitation

		Start		Post 1		*t*-Test
Groups	*n*	*M*	*SD*	*M*	*SD*	($p <$)
Combined (A + MH)	12	12.4	10.7	15.0	9.8	.05
Autism (A)	7	15.1	11.8	17.1	11.0	ns
Mixed handicap (MH)	5	8.6	8.6	12.0	8.1	ns
Normal preschool (NP)	10	23.1	5.7	23.6	4.4	ns

children with mixed handicaps, we again note that the normal preschool children obtain significant gains on all comparisons.

An inspection of the means indicate that, with one exception, the means increase progressively from the Start to Post 1 and Post 2. The only exception is noted for the children with autism. Here we observe a decline in phonological awareness after the end of the training period (Post 1–Post 2). Furthermore, we also note that the initial levels differ between the groups. The initial score observed for the normal preschool children (= .58) indicate that these children were much further along on their reading development than most of the children in the other two groups.

Sentence Imitation

The maximum score possible on the sentence imitation test is 25 and the obtained score (Table V) at Start for the normal preschool children was near ceiling ($M = 23.1$, $SD = 5.7$). This test was also relatively difficult to administer to the children with autism and mixed handicaps which is evident by the low *N*s for these two groups. Thus on this measure the most appropriate analysis was to combine the data from Groups A and MH and create a combined Developmental Disabilities group ($n = 12$). This comparison between Start and Post 1 comes out as clearly significant, $t(11) = 2.35$, $p < .05$. A nonsignificant effect is noted for each of the three groups of children considered separately.

Verbal Behavior and Motivation

Complete video observations of two lessons (one in the beginning and one towards the end of the training period) exist for most children in

Table VI. Verbal and Nonverbal Communication for Children with Autism (Group A, *n* = *11) at the Onset of the Training (Start) and at the End of the Training Period (Post 1)*

	Start		Post 1		
	M	*SD*	*M*	*SD*	*p*
Complies	10.9	5.8	8.1	4.6	.074[a]
Off task	8.7	9.0	6.5	4.5	
Seeks help	1.3	1.6	2.7	2.8	.029[b]
Verbal expression	27.7	12.6	34.2	15.3	.008[b]
Enjoyment	4.8	4.9	8.4	7.0	.026[b]

[a] Two-tailed test.
[b] One-tailed test.

Groups A and MH and Table VI gives the result for the children with autism. Strong positive changes are noted for the categories "verbal expression," "enjoyment," and "seeks help." That is, the children talked significantly more during their final lesson with Alpha ($M = 34.2$, $SD = 15.3$) than during their first training session ($M = 27.7$, $SD = 12.6$), $t(10) = 2.89$, $p < .01$. Since the category "off task" did not change over time it seems relatively safe to attribute the observed increase in verbal expressions to verbal interactions relevant to the teaching situation. Furthermore, the observed increase for the category "Seeks help," $t(10) = 2.14$, $p < .03$, indicates that the children more actively asked for assistance at the end of the training period. This might be a positive side effect caused by the observed increase in verbal expression, but could also be due to the fact that the children felt more comfortable with the CAI environment towards the end of the intervention.

A strong effect on motivational factors is also observed for the children with autism as revealed by an increase of almost 100% of observed expressions of "Enjoyment," $t(10) = 2.19$, $p < .03$. Thus, the children were much more likely to express positive feelings during the session at Post 1 ($M = 8.4$, $SD = 7.0$) than at the onset of the training ($M = 4.8$, $SD = 4.9$). One possible interpretation is that this finding is an effect of the motivational teaching environment created by the child, the teacher, and the program.

Finally, an almost significant decrease in the category "complies," $t(10) = 1.99$, $p < .10$, two-tailed) was observed for the autistic group. It is our view, having viewed and reviewed several of the tapes, that this decrease probably is an effect of the children being more self-confident and self-reliant after having worked with the program over a considerable length of time. There was no longer any need for the teacher to tell the child to pay attention. Instead, the children were more likely to be more self-efficient in dealing with the computer and maybe also more driven by inner motivation.

The resulting pattern for Group MH is somewhat different. The only effect is an almost significant increase ($p < .10$) in "verbal expression" coupled with no change for the category "off task." In other words, it can be inferred that the children in both groups increased their communication about relevant topics.

Prediction of Treatment Effects

The children's results on several measures at the beginning of the training was correlated (product-moment correlations) with their actual gains in reading, phonological awareness, and sentence imitation during the intervention period. Predictive measures used in this explorative analysis were the children's estimated mental age (MA), receptive language age (LA), initial sentence imitation score, initial phonological awareness score and the composite initial reading score. Table VII shows that MA was a relatively good predictor for gains in reading with a correlation of $r = .53$ ($n = 17$, $p < .05$) between Start and Posttest 1. A similar relationship was found for MA and gains in reading between Start and Post 2 ($r = .50$, $n = 16$, $p < .05$). Another strong predictor of reading was the initial sentence imitation score with a correlation of $r = .78$ ($n = 14$, $p < .01$) between Start and Post 2. However, the correlation between sentence imitation and reading gains between Start and Post 1, although positive, did not come out as impressive ($r = .32$, ns). In addition, LA did correlate modestly with reading gains ($r = .45$, $n = 16$, $p < .10$) but the initial reading or phonological awareness scores did not correlate with any of the observed gains in reading throughout the intervention period. Further analysis revealed that none of our measures succeeded in significantly predicting gains in phonological awareness or sentence imitation.

Table VII. Product-Moment Correlations Between Preintervention Measurements and Observed Gains in Phonological Awareness, Word Reading, and Sentence Imitation During the Intervention Period Proper (Start–Post 1) and from Start to Follow-Up Evaluation (Start–Post 2)

	Phonological awareness gain				Reading scores gain				Sentence imitation gain	
	Start to Post 1		Start to Post 2		Start to Post 1		Start to Post 2		Start to Post 1	
Predictor	*r*	*n*	*r*	*n*	*r*	*n*	*r*	*n*	*r*	*n*
Sentence imitation	–.03	14	.32	14	.32	14	.78[c]	14	–.39	12
Mental age	.40	15	–.00	15	.53[b]	17	.50[b]	16	.01	11
Language age	.06	14	.22	14	.30	17	.45[a]	16	–.53[a]	12
Phonological aw.	.08	15	–.26	15	.45	14	.00	14	–.29	8
Reading	.14	15	–.03	15	.18	18	–.03	17	–.16	12

[a] $p < .10$.
[b] $p < .05$.
[c] $p < .01$.

DISCUSSION

This study demonstrates that an interactive microcomputer learning environment might facilitate language learning for children with autism as well as for children with other handicaps such as cerebral palsy and mental retardation. All groups of children showed considerable progress during training and displayed significant increases in vocabulary as measured by the built-in Alpha tests. In addition, strong generalized gains beyond the Alpha materials were observed on tests measuring both word reading and phonological awareness, as well as sentence imitation. This held for all three groups of children although it appeared that the observed results for the comparison group indicate a less specific effect of the Alpha program. That is, the normal preschool children increased their language skills regardless of the intervention as judged by their gains during the period (Post 1 to Post 2) following Alpha instruction. However, Swedish day care is expected to provide some language-related training to children between 6 and 7 years old (e.g., rhyming songs to promote phonological awareness), and two of the children did start regular school during the follow-up period. (Until 1997 Swedish children start school at 7.) These two factors might, in part, explain why no specific intervention effect could be detected for the normal preschool group.

The gain in reading demonstrated in our study supports the hypothesis that CAI can have a specific input for children with autism and other handicaps. The combined results for both the children with autism and the children with mixed handicaps revealed an overall gain of 8% during the training period ($p < .01$) and a gain of 14% from the onset of training to the follow-up evaluation approximately one semester after training had ended ($p < .01$). More specifically by group, the children with autism increased their scores 11% ($p < .05$) and the children with mixed handicaps 5% ($p < .06$) during the training period.

The pattern of results observed for phonological skills also indicates a significant intervention effect for the combined results for Groups A and MH (a gain of 14%; $p < .05$) as well as for the children with autism (a gain of 16%; $p < .05$). A nonsignificant effect was observed for the children with mixed handicaps when their results were analyzed separately, although one must bear in mind that this group included only 6 children for this measurement. Due to a variety of physical disabilities it was not possible to test all the children in Group MH for phonological awareness. Furthermore, it is worth noting that the children with autism displayed a negative trend after the end of the intervention period (although this change in observed means fail to reach statistical significance) while the children in Group MH displayed a contrasting pattern with a significant gain of 21% ($p < .05$) from Start to the Post 2. This is consistent with the general clinical observation that children with autism in particular need continuing educational support in order to maintain the gains they have made.

Teacher–child dialogue relevant to the computer-assisted Alpha reading instruction was expected to contribute to children's gain in overall verbal level as shown in sentence imitation scores, and this hypothesis was confirmed for the children with autism and the children with mixed handicaps. Moreover, the children's actual behavior during the lessons, as shown by videorecordings, indicate that their verbal expressions increased significantly over time (from Start to Post 1). To be more specific, our intervention stimulated verbal exchanges focusing on the actual teaching situation since comments irrelevant to the teaching situations (category "off task") did not increase. These observations were most evident among the children with autism, but the children with mixed handicaps demonstrated a similar tendency. It was, however, only among the children with autism that we found that the category "enjoyment" increased significantly. Thus, one might argue that a highly motivating and interactive microcomputer program like Alpha has a strong motivational potential for children with various handicaps and, maybe, most pronounced for children with autism.

One is tempted to conclude that a CAI multimedia intervention can be very successful if employed with a selective group of children with autism and mixed handicaps. This is in line with our preliminary findings (Heimann et al., 1993a, 1993b) as well as the positive outlook presented by Panyan (1984) almost a decade ago, and previous effects of Alpha reported for the development of deaf and hearing-impaired children (Nelson et al., 1993). Our observations and findings are also interesting in the light of Colby's (1973) early results. Colby tried to create a highly motivating and a multi-modal-based setting for exploring language which he claimed to be successful. Our study and our intervention makes use of a similar strategy, at least to some degree. The aim was to create a teaching situation that promoted exploration, that gave the child immediate feedback through several different channels, and that was experienced as fun, rewarding and highly motivating by the child.

However, some caution is definitely in order before making too strong claims on the basis of one single, quasi-experimental, study. Since all children were preselected based on the teachers judgments about their readiness and willingness to learn language, one cannot automatically generalize our results to *all* children with autism or *all* children with cerebral palsy or *all* children with Down syndrome. A computer and a motivating multimedia program might be of help, but there is no absolute magic associated with the computer. For some children, other and different paths of learning must be explored and supported.

There are some additional factors to consider when interpreting the present results. First we experienced considerable missing data on some measures (due to teachers not carrying out all the tests they had been asked to do). The reason for this neglect was mostly a preconception on the part of the teacher of the test being too difficult to administer for a particular child. Second, we lost some subjects after the final selection process. This was particularly the case for the comparison group, where several subjects were lost for political reasons: Sudden and severe cutbacks decided by the city council of Göteborg made it impossible for the participating day care to continue. Third, both the children with autism and the children with mixed handicaps received intervention periods that were more than twice the length of that received by the normal preschool children. This variation between the groups was due to the design of the study, which took into account the variation in handicap observed between the children. Since both the level of cognitive and sensory impairments varied, it was expected that the children in Groups A and MH would need a longer training period. This was also confirmed by our observations since the children in the comparison group displayed significant increases regardless of the short intervention period received.

The large variation in observed results within each group of children are also important when discussing the findings. The increase in word reading skills was zero or almost zero for a couple of the children in each of the handicapped groups. Thus, one might be tempted to conclude that our intervention was less successful for the children displaying no or very low gains. However, this was not always the case. A good example of this are the results from one child with autism (with an additional diagnosis of severe mental retardation) who displayed no intervention effect as indicated by our reading tests. Nevertheless, she enjoyed the program with all its feedback and rewarding animations, and her regular teacher experienced a clear change in her attitude towards training of reading skills. For this child, Alpha did create a motivating environment although actual reading did not increase. One must also keep in mind that the intervention only lasted for approximately one semester, a rather short period if one wants to obtain a strong effect among children with severe mental retardation (see Howlin, 1989).

We also picked up other examples of how an intervention like the one employed in our study might have effects that are not covered by tests or video observations. One teenager with autism was a relatively good reader at the onset of training, almost too good to be included in the study. But he liked the program and constantly asked his teacher if he could work some more with Alpha. This boy did not show strong gains on our tests since he was already close to ceiling at the beginning, but he did start to combine words into two- and three-word sentences when asked to write down simple descriptions (e.g., when asked by his teacher to write a short note on what he did last weekend). To his teacher and his parents, this was a major achievement, and something he had never done before. Previously he had written his messages like telegraphic one-word sentences. A teenage girl in the mixed handicap group showed increased interest which surprised the mother and the teacher.

There are also examples of "not so positive" side effects of the program. A 19 year-old girl in the mixed handicap group, although initially motivated, grew more and more frustrated because of slow progress. This frustration affected her behavior both in school and at home, and it was her teacher and relatives that decided to take her off the intervention project. Another girl in the mixed handicapped group, who had shown considerable gains during the intervention, lost all the observed gains during the follow-up period. This might have been due to negative life events (she moved to a different institution), but might also, at least in part, be due to the fact that the program was taken away from her, a program that she liked and associated with positive attention from teacher's and relatives.

With all the above reservations, there is still room for optimism regarding the use of motivating multimedia language and literacy programs for children with autism as well as for children with other types of handicaps. Our findings point towards a positive effect of such a program. One must retain a cautious attitude because too high hopes might create frustration for both the child and the teacher or parent. However, if future interventions are based on careful assessments of the child's motivation and preintervention language levels, realistic gains may be achieved. Our data indicate that mental age, receptive language age, and a global language measure like the sentence imitation test are the three best predictors of gains in reading after computer-aided instruction as employed in this study. Thus, we feel that even if the program increases the rate of reading development by only a small percentage more than would be expected using regular teaching methods, interventions like the one we have described are well worth trying. And this is true even if the observed progress is limited to only a subgroup of children with autism. Hopefully, future intervention studies will continue to explore both the possibilities and the limitations of highly interactive computer-aided instruction for children with autism and other handicaps because we are still far from the extreme optimism advocated by Coldwell (1991a, 1991b).

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