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Enhancing Social Problem Solving in Children with Autism and Normal Children Through Computer-Assisted Instruction

Vera Bernard-Opitz,[1,2] N. Sriram,[1] and Sharul Nakhoda-Sapuan[1]

Children with autism have difficulty in solving social problems and in generating multiple solutions to problems. They are, however, relatively skilled in responding to visual cues such as pictures and animations. Eight distinct social problems were presented on a computer, along with a choice of possible solutions, and an option to produce alternative solutions. Eight preschool children with autism and eight matched normal children went through 10 training sessions interleaved with 6 probe sessions. Children were asked to provide solutions to animated problem scenes in all the sessions. Unlike the probe sessions, in the training sessions problem solutions were first explained thoroughly by the trainer. Subsequently these explanations were illustrated using dynamic animations of the solutions. Although children with autism produced significantly fewer alternative solutions compared to their normal peers, a steady increase across probe sessions was observed for the autistic group. The frequency of new ideas was directly predicted by the diagnostic category of autism. Results suggest young children with autism and their normal peers can be taught problem-solving strategies with the aid of computer interfaces. More research is required to establish whether such computer-assisted instruction will generalize to nontrained problem situations in real-life contexts.

KEY WORDS: Autism; social problem solving; computer-assisted instruction.

INTRODUCTION

Problem solving, conflict resolution and empathy are core components of "emotional intelligence," a construct popularized in recent years by Goleman (1997, 1998). He presented a body of research implying that, in addition to cognitive inputs, effective learning is powerfully modulated by variables in the social and emotional domains. Various child development projects and school centers in the Western world have emphasized social competence or self-science in their curricula (Elias, 1992). These skills are taught to children as young as 4 years old and form the basis for books, training programs, and videotapes for children (Berry, 1995).

Children with autism show significant problems in the domains of communication, emotion recognition, empathy, and social skills (Happé, 1994; Wing, 1990). They often fail to process subtle transient stimuli such as expressed emotions and are overwhelmed by the complexity of social settings (Hobson, Ouston, & Lee, 1989; Prior & Ozonoff, 1998; Volkmar, Cohen, Bergman, Hooks, & Stevenson, 1989). If conflict arises, inappropriate coping strategies such as withdrawal or severe tantrum behaviors have been observed. Lack of understanding the emotional states of others, and a deficient Theory of Mind, has been identified as one of the deep-rooted problems that need to be tackled for this population (Baron-Cohen, Leslie, & Frith, 1985; Howlin & Baron-Cohen, 1999; Ozonoff & Miller,

[1] Department of Social Work and Psychology, National University of Singapore.

[2] Address all correspondence to Vera Bernard-Opitz, Department of Social Work and Psychology, National University of Singapore, 11 Law Link, Singapore, 117570; e-mail: swkberna@nus.edu.sg

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1995). Some of these children manage to achieve normal academic standards in mainstream educational settings. However, their poor social awareness, low flexibility, and awkwardness in social settings have limited the success of their integration into mainstream schools.

On the other hand, children with autism demonstrate relatively good skills in responding to fixed visual cues such as pictures or written words (Quill, 1997). Parents, too, report fascination and good learning rates through watching videos or computers. Research has supported these reports by effectively teaching communication skills and specific social scripts through computer programs (Heiman, Nelson, Tjus, & Gilberg, 1995).

These findings suggest that an appropriately designed computer program could be an effective aid for teaching problem-solving skills to children with autism. A program was developed to present everyday conflicts and elicit solutions. For example, two children would be fighting over their turn to use a slide in the playground. This was followed by icons representing animated alternative problem solutions such as making a polite request versus throwing a tantrum. Children were also requested to produce alternative solutions; these were reinforced by short clips of a satisfactory resolution to the conflict and access to any one of eight reinforcing scenes. We hypothesized that exposure to animated solutions and the reinforcement of alternative solutions would jointly enhance the production of the latter. Based on the finding that sensory reinforcers enhance the learning rate of young children with autism (Rincover, 1978), participants could choose among sensory (e.g., dynamic spirals) or natural reinforcement, animation related to the problem setting (e.g., after having bargained for a toy bus, boy is shown driving happily around with the bus). We hypothesized that both normal children as well as children with autism would show generalization by producing alternative solutions on nontrained problems. We also wanted to contrast the learning rates of children with autism and normal children in nontrained problem situations.

METHOD

Procedure

In collaboration with a Singaporean computer firm, IT 21, a computer program presenting eight conflict settings was developed to be run from the CD-ROM on Windows 95 based PCs (Table I). Some of the conflicts were modeled after the training program by Shure on “I can Problem-Solve” (Shure, 1992). Others were tailored to reflect the contextual knowledge of Singaporean children (e.g., not being able to reach the rambutan fruits on a tree). Four easy and four difficult problems were pictured with cueing options for various possible solutions. Eight distinct social problems were presented, along with a choice of possible solutions, and an additional option (indicated by a light bulb) for producing alternative solutions. Problems differed in level of difficulty to assure that participants of various levels could be successful as well as challenged by them. In easy conflicts, the child had to find solutions to everyday problems such as not getting his turn or not being able to reach an item. By contrast, difficult conflict settings illustrated higher level social problems such as not having sufficient money to buy a desired item or being scolded for breaking an object. The distinction between “easy” and “difficult” problem settings was based on consensus among the program designers.

Table I. Settings on Social Problem Solving

Easy level	Difficult level	Targets
1. Boat	5. Slide	Taking turns
2. Rambutans	6. Bicycle	Requesting for help/objects
3. Fish	7. Eggs	Giving in
4. Bus	8. Money	Negotiating

Problem settings were illustrated by animations that also incorporated recorded speech using children’s voices. Children were cued by a computer voice to solve the problem (e.g., “What would you do?”). Pictures presenting two appropriate and two inappropriate options were given. While these pictures were static and only briefly described by the trainer during baseline sessions, they were animated and explained by the trainer during training. Participants were also prompted by a light bulb to verbally produce ideas. (“Do you have any good ideas?”). Novel ideas not shown in the pictured alternatives were reinforced, if they were appropriate to the problem. Inappropriate solutions were ignored. Upon the production of an innovative idea, a computer voice praised the child with a “happy end” to the conflict, such as the animation of children taking turns, and sharing toys or food. After this scene, the child could select from eight pictures, leading to additional reinforcement. Four sensory conditions (such as spirals or lines) and four natural conditions (such as a child jumping on a trampoline or rabbits coming out of a magician’s hat) were included. Once a child had seen the reinforcing component, he returned to the orig-

Table II. Baseline Settings Across Participants

Autistic children			Normal children		
Name	Baseline		Name	Baseline	
A4	Fish	Bicycle	N4	Fish	Slide
A5	Bus	Eggs	N6	Bus	Money
A1	Fish	Money	N8	Rambutans	Slide
A3	Bus	Bicycle	N3	Rambutans	Bicycle
A2	Rambutans	Money	N7	Fish	Bicycle
A7	Bus	Slide	N1	Bus	Bicycle
A6	Fish	Eggs	N2	Fish	Eggs
A8	Boat	Slide	N5	Boat	Bicycle

inal problem setting and was requested to give additional ideas. When the child stopped producing new ideas on a particular problem, the trainer activated a new problem setting. In a session, children went through two easy and two difficult problem situations. The assignment of situations was randomized across children and sessions (Table II). Overall each child participated in ten training sessions.

Prior to and during the training each child was assessed for his responding to four nontrained conflict situations. The first and fourth probe session coincided with the first and ninth learning sessions while the two other probes were randomly chosen to coincide with two in-between sessions. In the probe sessions, children were not given explanations of possible solutions nor were they shown animations illustrating these solutions. The number of good ideas was checked for reliability in 87% of the video samples. The interobserver agreement on production of good ideas was .97 for normal children and .94 for children with autism.

Participants

Out of a group of 176 children with autism 15 verbal children were considered as possible candidates for the study. Participants were selected if they had an autism score above 65 and an IQ in the normal range. All children were diagnosed using the Autism Behavior Checklist (ABC: Krug, Arick, & Almond, 1979). Eight children with autism and eight normal preschool children participated in the experiment (Table III). All the children came from middle class, English-speaking Singaporean families, and were of Chinese ethnicity. Originally 10 children were planned for each group, but participants dropped out due to illness and other unforeseen circumstances. Children with autism ranged

Table III. Cognitive Functioning and Language Comprehension[a]

				K-Bit		BPVS	
Participant	Sex	Autism scores	Age (years:months)	Composite standard score	Vocabulary standard score	Standard score	Age equivalent
Autism							
A1	M	68	8:1	108	79	69	5.0
A2	M	70	7:1	103	92	79	5.0
A3	M	68	8:5	108	109	88	5.0
A4	M	69	8:5	98	89	68	5.2
A5	M	72	7:4	102	92	77	5.1
A6	F	70	5:8	109	100	88	4.7
A7	F	70	5:8	110	102	89	4.8
A8	M	70	7:4	93	87	71	4.6
Average			7:1	104	94	79	4.9
Normal							
N1	F		4:4	127	124	102	4.4
N2	M		4:0	109	111	106	4.4
N3	F		4:5	126	112	99	4.3
N4	M		4:9	97	89	97	4.6
N5	F		4:9	103	100	92	4.1
N6	M		4:9	97	107	94	4.3
N7	M		4:4	128	117	100	4.2
N8	M		4:6	122	119	101	4.5
Average			4:6	114	110	99	4.4

[a] K-Bit = Kaufman Brief Intelligence Test, BPVS = British Picture Vocabulary Test.

in age from 5.8 years to 8.5 years with a mean of 7.1 years. The normal preschool children were a more homogeneous and significantly younger group with a mean of 4.56 years (range: 4.0 to 4.9). An attempt was made to match normal and autistic children on their general cognitive functioning using the Kaufman Brief Intelligence Test (K-BIT; Kaufman & Kaufman, 1990) and on their language comprehension using the British Picture Vocabulary Scale (BPVS, Dunn, Dunn, Whetton, & Pintilie, 1981).

The groups did not differ significantly in their overall composite standard score, ($M_{\text{autistics}} = 103.9$, $M_{\text{normal}} = 113.6$), $t(14) = 1.8$ $p > .05$, (see Table III), but autistic children showed significantly lower standard scores on comprehension (BPVS) compared to the normal children ($M_{\text{autistics}} = 76.4$, $M_{\text{normal}} = 98.9$) $t(14) = 6.9$, $p < .001$. Note, however, that the age equivalence BPVS scores were higher for children with autism ($M_{\text{autistics}} = 4.93$, $M_{\text{normal}} = 4.35$), $t(14) = 6.2$, $p < .001$ (see Table III). In absolute terms, performance of the autistic children on BPVS and K-BIT was comparable to the normal children; however, as they were older, their standard, age-corrected scores were considerably lower than the normals.

RESULTS

The principal dependent measure was the number of novel ideas produced during the probe and training sessions. Repeated-measures ANOVA was conducted for the data from the two session types with autism as a between-groups variable. The mean number of novel ideas across sessions was used in another repeated-measures ANOVA contrasting the two session types. The efficacy of autism in predicting production of novel ideas was contrasted with individual differences in unstandardized scores on IQ and comprehension using multiple regression.

Training Sessions

Compared to normal children, children with autism had a significantly lower number of novel ideas produced in the training sessions (*M*s = 2.25 vs. 6.9), $F(1, 14) = 27.3$, $p < .001$. There was a trend of greater productivity as the sessions progressed, $F(9, 126) = 5.3$, $p < .01$. Figures 1 and 2 reveal that this trend differed across the two groups, $F(9, 126) = 2.1$, $p < .05$. The effect of training was more consistent for normal children (see Fig. 3); after 4 to 6 computer sessions these children showed rapid improvement of produced ideas, usually doubling the number of ideas from the initial sessions. For children with autism this trend was variable. An increasing trend was evident for five children whereas three children did not increase their productivity of ideas (Fig. 4). All three subjects (A6, A7, & A8) had the lowest verbal age equivalent (<5 years). They started out with the lowest number of solutions during the baseline sessions.

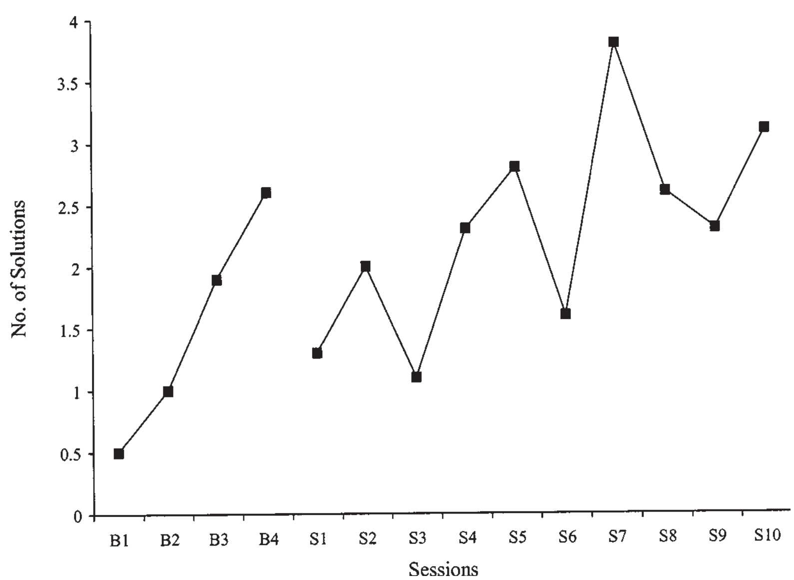

Fig. 1. Problem solutions of children with autism.

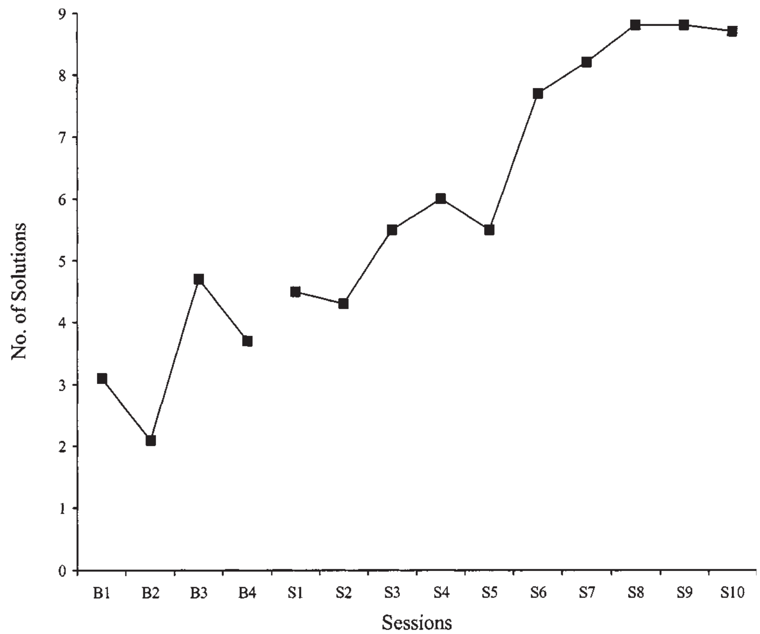

Fig. 2. Problem solutions of normal children.

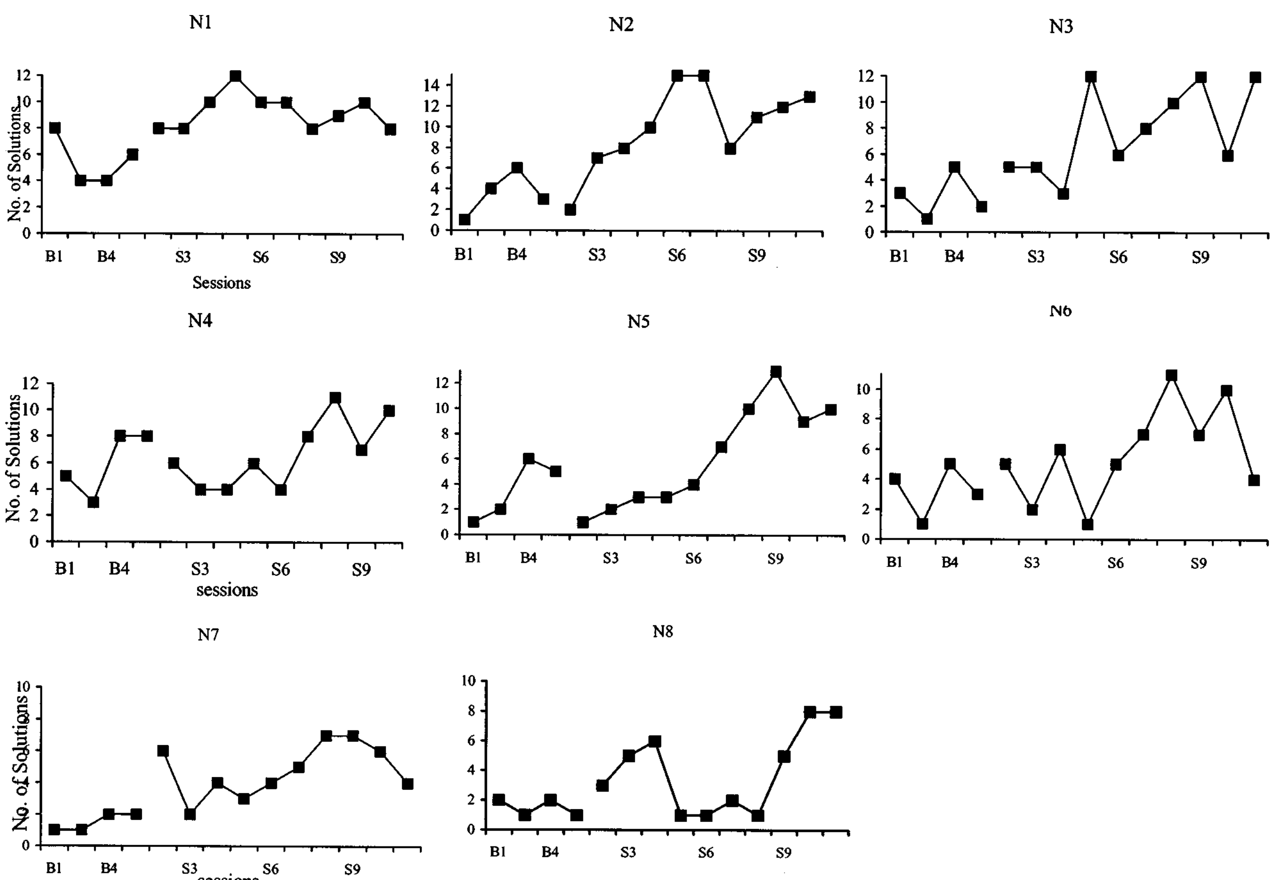

Fig. 3. Normal children on producing appropriate solutions.

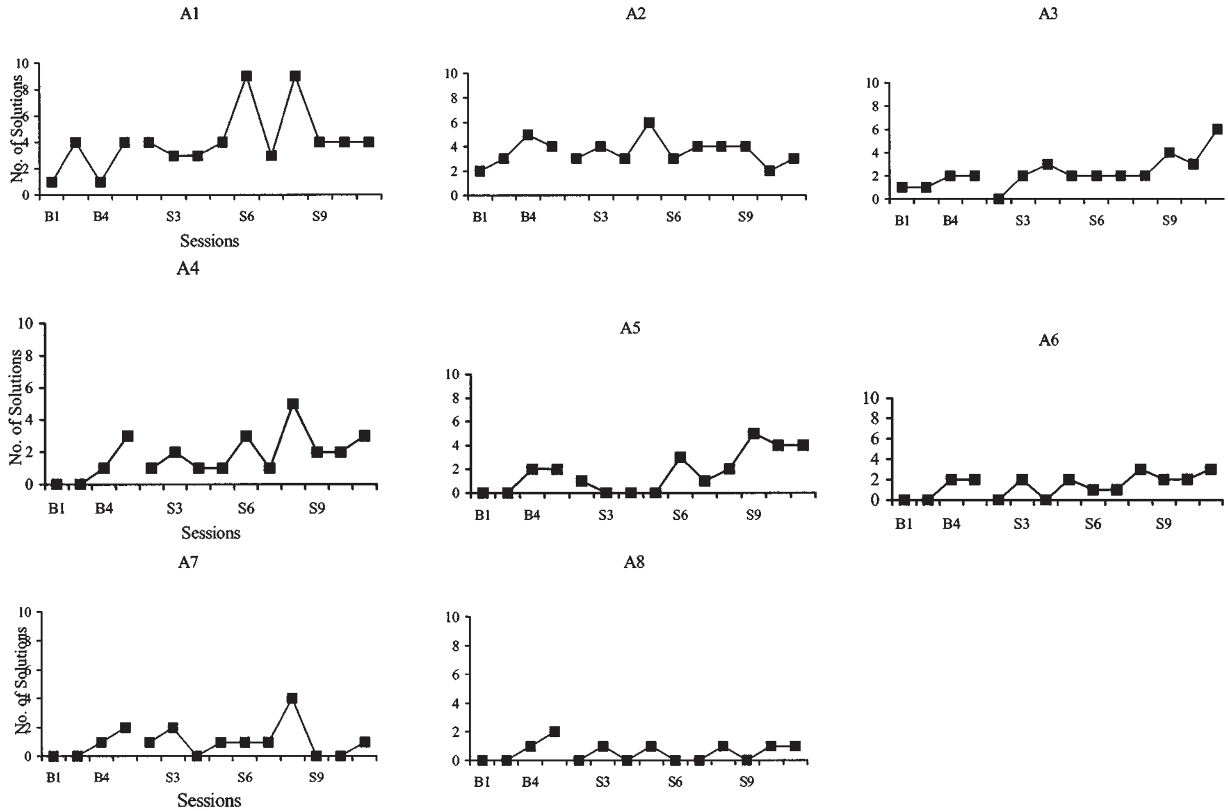

Fig. 4. Children with autism on producing appropriate solutions.

Probe Sessions

A repeated-measures ANOVA revealed that performance in the probe sessions was markedly lower than that in learning sessions (2.47 vs. 4.57), $F(1, 14) = 39.7$, $p < .001$. The lower productivity of children with autism was also evident in the probe sessions (1.5 vs. 3.4), $F(1, 14) = 8.2$, $p < .05$. Performance increased across the four probes, $F(3, 42) = 8.9$, $p < .001$, indicating that the improvement in the training sessions was also reflected by the probes. Even though the number of solutions given during baselines was small (2 to 5 solutions), an increase across probes was observed for seven out of the eight autistic participants (see Fig. 1). This may be considered to be preliminary evidence for the generalization of problem-solving strategies to untrained conflicts for young children with autism.

Predictors of Productivity

In addition to autism, it is plausible that individual differences in receptive and expressive vocabulary might account for the variability in the production of novel ideas. To test this possibility, we carried out a multiple regression wherein the production of novel ideas was predicted from three variables; autism and unstandardized values of expressive and receptive vocabulary. This regression model accounted for over 70% of the variance ($R^2 = .702$). The productivity of new ideas was solely predicted by autism ($\beta = 1.08$, $t = 3.48$, $p < .005$); it was unrelated to the absolute values of expressive and receptive vocabulary (β's = .153 and .229, ts $= -.41$, 1.2, ps $> .20$). These results suggest that, in this sample, the productivity of novel ideas was directly related to the diagnostic category of autism. If the regression model excluded autism, the adjusted R^2 dropped to .31 from .62 and both the regression coefficients failed to reach significance.

Comparing Reinforcer Choices for Autistic and Normal Children

Children with autism showed a significant preference for sensory reinforcers over natural reinforcers, which they selected in 61% of the cases. The normal peers preferred them only in 40% of the cases. More important, only one normal child had a value that was in the range of preference for children with autism (Table IV).

DISCUSSION

The above results affirm that normal and autistic preschool children can be taught social problem solving using animated models of problem solutions presented by a computer. Although the dramatic increase in novel ideas produced by normal preschool children is not surprising, the results also give hope for young autistic children. They complement recent findings on teaching autistic children social skills through video modeling and pictured time schedules (Quill, 1997). Using predictable animation of real life problem settings not only enhanced the production of increasing numbers of solutions but also influenced performance on untrained problems. The improvement in production across probe sessions was present in both groups but was clearer for autistic children. In comparison to normal preschoolers, children with autism favored sensory over natural reinforcement, supporting previous research on sensory stimulation (Rincover, 1978).

Care must be taken in interpreting the data because of limitations regarding the subject sample, the definition of the dependent variable, and the restricted array of trained and tested problem settings. The sample was drawn from autistic children with normal intelligence, a population that constitutes only about 25% of the general population of children with autism. Although participants with autism learned to produce novel ideas, their productivity of problem solutions was significantly lower than that of normal children. Using predictable animation of real life problem settings not only enhanced the production of increasing numbers of solutions but also influenced performance on untrained problems.

Table IV. Percentage of Recognized and Sensory Choices

Participant	Recognized problems (%)	Sensory choices (%)
Autism		
A1	100	50
A2	100	50
A3	100	72
A4	90	47
A5	100	87
A6	100	66
A7	100	62
A8	100	57
Total	98	61
Normal		
N1	100	41
N2	100	41
N3	95	43
N4	97	43
N5	97	15
N6	97	56
N7	93	38
N8	100	40
Total	97	40

The developed software package encompassed conflicts in taking turns, communicating, and bargaining, which have been described in the problem-solving program by Shure (1992). Although these problems seemed important for the included children, they are just a small selection from the vast array of potential conflict situations.

The dependent variable was the number of appropriate problem solutions. This might not necessarily be an appropriate indicator of adequate problem solving even though this criterion is also adopted by problem-solving programs that require the generation of alternative solutions (Camp & Bash, 1985).

Our study focused only on the children's responding during a computer program and did not assess generalization to real life settings or other tests on problem solving. A recent study in our laboratory indicates that generalization of problem solving to real life settings critically depends on the similarity between the simulated and in vivo problems. In a crossover multiple baseline design across four children with autism, the computer-presented problem of getting help to reach the rambutan fruits on a tree generalized to the real setting of a helium balloon out of reach, but did not generalize to a bargaining situation, which had not been trained (Tan, 2000).

Observational data indicated that the autistic children enjoyed the programs, while the normal preschool children showed signs of boredom in the later sessions of the study. Objective enthusiasm assessment and social validity measures would serve as useful collateral data in future studies.

There are several implications of our research. Simulating social problem solving with the aid of computer programs might be a possible new avenue to enhance social problem solving for normal children as well as high-level children with autism. Whether behavior learned in the computer setting generalizes to the real setting might depend on the similarity of the trained problem to the untrained problem (Tan, 2000). Further research is necessary to identify problem settings relevant for the development of social skills in people with autism across the life-span. It also seems important to compare teaching methods aimed at standard social scripts and the development of cognitive sets such as the set in our study to have another "good idea." Further exploration is required to determine whether brainstorming skills acquired through computer programs can lead to general increases in flexible thinking. Teaching of cognitive sets regarding "good/new ideas" or "try a new way" might be a relevant pivotal skill (Koegel & Frea, 1993) to counter the rigidity of people with autism in social interactions, communication, play, or insistence on sameness.

Properly designed, computer programs can assist the teaching of conflict solutions, brainstorming, and consequential thinking to young children, from age 4 years onwards. Such programs exemplify the possibility of teaching components of emotional intelligence to parents and teachers. Since self-help books and books on emotions for young children have sold in the millions (Berry, 1995), computer programs with this focus might also have a similar potential. They also might give parents and educators a demonstration of alternative thinking strategies in conflict situations, self-management methods, and the power of reinforcement (Meichenbaum, 1976).

In the Asian context, parents and teachers seem more accepting of computer programs than role-play, think-aloud strategies, or self-control exercises that have similar goals. While the local education system increasingly recognizes the need to incorporate thinking skills, creativity, and emotional intelligence into the curriculum, parents and teachers continue to place high priority on reading, writing, and arithmetic. About 50% of all Singaporean children receive tuition, starting from kindergarten, targeting the 3 Rs. This bias in favor of literacy and numeracy ignores findings suggesting that school success depends crucially on emotional and social variables rather than hinging entirely on factual knowledge and reading skills (Head Start, 1992).

For children, adolescents, and adults with autism, computer programs modeling everyday conflicts and their solutions might be a possible avenue to reduce problem behavior in real-life settings, teach divergent and consequential thinking, and appropriate social scripts. Multidisciplinary approaches, involving educational specialists, psychologists, programmers as well as parents and their child with autism, could be useful. Although real-life practice remains the most important part of social problem solving, computer-based simulations might be a nonthreatening starting point for individuals with autism, contributing to the facilitation of better social and communicative competence.

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