Journal of Behavioral Education, Vol. 13, No. 2, June 2004 (© 2004), pp. 83–91

Stimulus Control with Computer Assisted Learning

Jose I. Navarro, Ph.D.,[1,2] Esperanza Marchena, Ph.D.,[1]
Concepcion Alcalde, Ph.D.,[1] and Gonzalo Ruiz, Ph.D.[1]

Computer Assisted Learning (CAL) has been shown to be an efficient learning-teaching procedure. Although there is an extensive educational software tradition using CAL approaches, few of them have demonstrated a better student performance than standard drill and practice methods. The purpose of this study was (a) to evaluate the effectiveness of the "Let's Play With . . ." software program, and (b) to evaluate the effectiveness of a prompt (i.e. a blinking object) used in the program. The educational software "Let's Play With . . ." was designed to teach basic concepts involving shapes and body positions to preschool students. The software structure follows a behavioral design and uses a stimulus control procedure. The study was carried out with 64 preschool students in the Cadiz (Spain) School District. Statistically significant differences were found between the experimental group and a control group.

KEY WORDS: Computer Assisted Learning; stimulus control; learning.

Behavioral Psychology has emphasized the relationship between an instrumental response and a reinforcer, as it is a very important aspect of instrumental conditioning. Responses and reinforcers, however, do not occur in a vacuum (Danforth, Chase, Dolan & Joyce, 1990; Domjan & Burkhard, 1986). Because the instrumental response is reinforced in the presence of stimuli, these stimuli may effectively control the response. Stimulus control of behavior is an important facet of adjusting behavior to the context.

Antecedent events, such as cues, instructions, gestures, directions, examples and models, can facilitate the development of a behavior. Events that help initiate a response are referred to as prompts. Prompts are supplementary stimuli used to increase the likelihood that a correct response will be emitted in the presence of a

[1]Department of Psychology, University of Cadiz, Cadiz, Spain.
[2]Correspondence should be addressed to Jose I. Navarro, Ph.D., Department of Psychology, University of Cadiz, 11510 Puerto Real, Cadiz, Spain; e-mail: jose.navarro@uca.es.

1053-0819/04/0600-0083/0

potential discriminative stimulus. Stimulus prompts are cues used in conjunction with the task stimuli or instructional materials (Cooper, Heron & Heward, 1987; Kennedy, 1994). Martin and Pear (1983) present several reasons for using prompting procedures that result in fewer student errors. First, errors decrease the time available for teaching. Second, when an error occurs it is likely to be repeated. Third, the lack of reinforcement may result in inappropriate behaviors.

Learning can be facilitated in different ways using various kinds of prompts, such as physically guiding the behavior, instructing a child to do something, gesturing to the child or observing another person (a role model) performing a behavior (Wolery, Bailey & Sugai, 1988). Snell (1983) identifies three techniques for prompting a behavior. The first technique is the use of movement cues, the second is the use of position cues, and the third is the use of redundant cues. Redundant cues occur when one or more stimuli (e.g. blinking) are paired with the stimulus that is discriminative for the correct choice (Skinner, 1978).

Considering previous research (Dube & McIlvane, 1989; Dube, 1991; Ferretti, l993; Schreibman, 1975), most Computer Assisted Learning (CAL) has not been designed using functional analysis-based criteria (Bailet & Weippert, 1992; Murray, 1992). More specifically, studies with preschool students using CAL approaches frequently have not used stimulus control principles (Harrison, Hay, Pierson & Burton, 1992; Klein & Nir Gal, 1992). The purpose of the present study is to implement an experimentally developed software ("Let's Play With . . ." ©) that uses a redundant cue prompting technique, in order to evaluate the (a) overall effectiveness of the "Let's Play With . . ." software and (b) effectiveness of the prompting procedure (i.e. a blinking object) embedded in the software.

METHODS

Participants and Setting

A total of 64 preschool students were selected (41 boys and 23 girls), between the ages of 35 and 46 months, with a normal IQ. Pretests established that none of the students knew the basic concepts of shapes and body positions.

A computer was placed in the children's regular classroom ten days before the beginning of the procedure, so that subjects got used to its presence. It was placed in a corner of the room, and separated from the rest of the room by a folding screen. The experimental sessions were carried out individually with each student by the researchers, with no other person present behind the screen during the course of the session.

Experimental Design

A between group design was used involving an experimental group and a control group. The participants were randomly allocated to the two groups, which were composed of 32 participants each. The presence or absence of a blinking prompt constituted the difference between the experimental group and the control group.

Dependent Measure

The dependent measure was the number of errors made by the student on each item displayed on the screen during the trials. Each time the student picked the wrong stimulus on the screen, the program registered one error. Errors were automatically recorded by the computer and stored in a retrievable file with the File Maker Pro program. Each subject's results for every session could be printed on paper, so that teachers had complete information on the students' progress.

Materials

Software

The "Let's Play With . . . " software was designed with the following goals: to facilitate learning, to motivate the student, to be very simple to operate, to be based on behavioral principles using a redundant cue prompting technique, to be interactive, to present different levels of difficulty, and to be useful for evaluating and analyzing learning.

Nine software programs were developed, involving two different instructional concepts (shapes and body position). The computer programs have three levels of difficulty: easy, average and hard, depending on the complexity of the stimuli displayed.

The "Let's Play With . . . Shapes" software involves discrimination learning of the concept pairs: open/closed, round/non round, square/non square. It is composed of 16 items arranged from the lowest to the highest level of difficulty. Simple pictorial stimuli drawn from a child's daily life were used. The first item involves a screen with two children's heads. The child on the left has his eyes open, and the one on the right has his eyes closed. The computer asks the child to "pick the child with open eyes." This stimulus (open-eyes) blinks, as a prompt, until the child uses the mouse to select it. Each correct response produced screen presentations with sounds and cartoons that provided immediate positive feedback. Each error was followed by a dissonant sound. The cartoons and dissonant sound were selected after a pretest to evaluate their effectiveness as behavioral consequences. Participants were asked to choose from four stimuli: a clicking sound, a dissonant sound, a cartoon, and clapping. The position of the stimuli was randomized across trials. The rest of the items in the software have a similar structure, but different illustrations are used.

"Let's Play With . . . Body Positions" involves discriminating body positions in space (standing, prone, on his/her knees, sitting). The structure of the program is similar to that of "Let's Play with . . . Shapes," but different illustrations are used.

Equipment

In this experiment, an Apple Macintosh Quadra 700 with an RGB color and touch sensitive screen for input was used. The interface had a Macintosh standard sound card, 20 MB RAM memory and an 80 Mb Hard Disc.

Procedures

Pretest

The Basic Concepts Figure Test (BCFT) (Alcalde & Marchena, 1996) was used for assessment of children's knowledge of basic concepts. BCFT is a paper and pencil, individually administered measure for preschool children. Students are required to pick 16 pictures related to shapes, colors and body position concepts. The test has two forms (A and B) that each contain different pictures. Form A was administered in the pre-treatment phase of the experiment.

Intervention

After the BCFT (Form A) was administered, the experimental group was given the "Let's Play With . . . Body Positions" and the "Let's Play With . . . Shapes" computer programs during two sessions each: Session l without the blinking prompt, and Session 2 with the prompt incorporated. The subjects in the experimental group were given all three levels of difficulty for each program in a single session, 16 trials per level. Therefore, each of the students received a total of 96 trials per session. The program did not repeat trials after errors. Instructions were given by the computer as follows across sessions: "This is a game, and now I am going to ask you to pick different objects displayed on the screen. So, pay attention and answer when you are sure of the answer." The computer then presented the instruction for the first trial, continuing until a total of 16 trials were completed at each level (e.g., "pick the boy who has his eyes open"; "pick the open book"; "pick the twisted line").

The control group was given the "Let's Play With . . . Body Positions" and the "Let's Play With . . . Shapes" computer programs in two sessions, both without the blinking prompt. Each of the students received a total of 96 trials per session.

Post-test

Form B of the BCFT was administered in the post-treatment phase. Forms A (administered as a Pre-test) and B are equivalent ($r = .87$; $p < .001$), and the test items are different from items in the training program. In addition, the participants were presented with a 16 trial generalization test, which used 16 questions referring to 16 real toys (such as balls, cartoons, small cars, or telephones). Differences between the toys were related to shapes and positions in space. Students were given instructions like "pick the toy with a round shape," "pick the twisted paper." Generalization testing was carried out two days after the last treatment session.

RESULTS

Table I presents the frequency distribution of scores for "Lets Play With . . . Shapes" and "Lets Play with . . . Body Positions" during sessions 1 and 2 for the experimental and control groups. Subjects under experimental conditions showed a reduced number of errors in session 2, when the prompt was activated.

Table II displays the mean number of errors and the ANOVA for "Lets Play With . . . Body Positions," session 1 and session 2, for both the experimental and control groups. Statistical significance favoring the experimental group was found when sessions 1 and 2 for "Lets Play With . . . Body Positions" were compared between groups ($F(6, 25) = 4.57$, $p < .001$).

Table III displays the mean number of errors and the ANOVA for "Lets Play With . . . Shapes." The experimental group made fewer errors than the control group ($F(6, 25) = 5.97$, $p < .001$).

The number of errors made by the experimental group declined between the first and the second instructional sessions ($p < .001$), but no such difference was found for the control group ($p < .06$). The ANOVA (f.d. = 31), with an overall value of $p < .001$ for the "Let's Play With . . ." programs, indicates a significant

Table I. Frequency of Errors Distribution for "Lets Play With . . . Body Positions" and "Lets Play with . . . Shapes"

Number of errors	Lets Play With . . . Body Positions				Lets Play with . . . Shapes			
	Experimental group		Control group		Experimental group		Control group	
	Session 1	Session 2	Session 1	Session 2	Session 1	Session 2	Session 1	Session 2
0–10	8	21	9	8	9	19	10	12
11–20	14	4	9	13	15	6	14	16
21–30	6	4	11	5	1	2	2	1
31–40	1	4	1	2	3	3	4	2
41–50	1	2	—	2	4	1	1	1
51–60	1	1	1	1	—	1	1	—
61–70	—	1	1	1	—	—	—	—
71–80	—	1	—	—	—	—	—	—
81–90	1	—	—	—	—	—	—	—
>90	—	—	—	—	—	—	—	—
n	32	32	32	32	32	32	32	32

Table II. Mean and *SD* of Errors, and ANOVA for "Lets Play With . . . Body Positions"

	Experimental group			Control group		
	Mean	*SD*	*n*	Mean	*SD*	*n*
Session 1	18.1	1.3	32	20.3	2.2	32
Session 2	1.91	0.02	32	18.1	1.3	32

Analysis of variance for "Let's Play With . . . Body Positions"

Source	*df*	Sum squares	Mean square	*F*
Control group	6	6.124	0.021	0.54
Experimental group	25	14.751	0.59	4.57***
Total	31	20.875		

*** $p < .001$.

Group by Time of testing interaction with a simple main effect for Time of testing in the experimental group, but not in the control group ("Let's Play With . . . Body Position" $F = 4.57$; "Let's Play With . . . Shapes" $U = 5.97$).

Table IV displays the mean number of errors for the generalization test for the experimental and control groups. Mean comparison testing was used, and statistical significance favoring the experimental group was found (Mean Differences = 5.8, $p < .001$).

Finally, pre- and post-treatment BCFT (Form A *vs*. Form B) results were statistically analyzed. Table V displays mean, standard deviations and comparison between pre- and post-treatment for the experimental and control groups. The experimental group made fewer errors than the control group (Mean Differences = 6.1, $p < .001$).

Table III. Mean, *SD* of Errors, and ANOVA for the "Lets Play With . . . Shapes"

	Experimental group			Control group		
	Mean	*SD*	*n*	Mean	*SD*	n
Session 1	14.7	1.4	32	15.6	1.7	32
Session 2	2.1	0.3	32	13.1	0.5	32

Analysis of Variance for "Let's Play With . . . Body Positions"

Source	*df*	Sum squares	Mean square	*F*
Control group	6	9.124	1.021	0.84
Experimental group	25	34.751	0.89	5.97***
Total	31	43.875		

*** $p < .001$.

Table IV. Mean, *SD* of Errors, and Mean Comparison for Experimental and Control Groups in the Generalization Test

Experimental group			Control group		
Mean	*SD*	*n*	Mean	*SD*	*n*
1.4	0.4	32	11.3	1.2	32
Mean differences experimental vs. control = 5.8***					

***$p < .001$.

DISCUSSION

The assessment of the effect of the blinking prompt on performance on the "Let's Play With..." program compared the mean number of errors in the first session (without blinking prompt) with the mean number of errors in the second instructional session (with blinking prompt). The total number of errors in session l was significantly higher than in session 2 ($p < .001$). Since the only difference between both sessions was the introduction of an object blinking on the screen as a prompt, it is reasonable to conclude that the prompt exerted stimulus control over the students' selections.

Given the results, and considering that the position of the blinking object was randomized across trials, it is reasonable to assume that students' performance was due to a discrimination process. The blinking prompt turned out to be relevant and useful, resulting in control of learning (Saunders & Spradlin, 1989). Acquisition of discriminations by young, normally developing children has also been reported by Lipkens, Hayes, and Hayes (1993), and Pilgrim, Jackson, & Galizio (2000).

Clearly, the 3-year-old preschool students were sensitive to the blinking object as hypothesized. However, additional analysis is required to understand why this type of stimulus resulted in "control" of the behavior. Some relevant questions to explore are: (a) whether a blinking object is the most appropriate stimulus in Computer Assisted Learning with young students, (b) whether other dimensions of the stimulus could more efficiently control the student's response, or (c) whether different types of discrimination (e.g., prompts of different intensity) would control the responses more efficiently.

Table V. Mean, *SD* of Errors, and Mean Comparison for Experimental and Control Groups in the Pre- and Post-Treatment Basic Concepts Figure Test

	Experimental group			Control group		
	Mean	*SD*	*n*	Mean	*SD*	*n*
Pre-test	11.4	0.5	32	13.3	0.2	32
Post-test	2.4	0.3	32	10.6	0.8	32
Mean differences experimental vs. control = 6.1***						

***$p < .001$.

The student must differentiate between the relevant aspects of a task and the merely secondary, or irrelevant, ones. The blinking prompt facilitates the discrimination of critical elements in the situation. Thus, the students are able to use this learning later in a familiar situation and to recognize it in new situations and settings (Thomas, l990). In the situations used in our study, subjects managed to discriminate between blinking and non-blinking stimuli, presumably because of the salience of blinking compared with fixed stimuli. This discrimination seems to facilitate the identification of relevant aspects of the situation, the discrimination of which, in its turn, has been shown to transfer later in both familiar and new situations.

Through the "Let's Play With . . ." computer program, children are able to learn the concepts in a flexible way, avoiding unnecessary errors which could lead the child to applying this knowledge in incorrect ways. Furthermore, it is necessary to resolve the effects of negative interference (Anderson, l99l). The transfer demands that the participants identify or recognize common elements from a computer program in a different situation (i.e. pencil and paper test). This transfer was observed in the students in this study when they were assessed with the BCFT (see Table V). Participants from the experimental group with a higher performance on the training session made fewer errors on the form B of the BCFT posttest.

Even though the pace at which computers are being introduced into educational settings is sporadic and uneven, the process will be facilitated if teachers can make more effective use of these tools in their classrooms. In this sense, "Let's Play With . . ." is an instructional program capable of generating specific responses. This has been shown not only with the students in this study, but also with children with intellectual disabilities (Alcalde, l996; Alcalde, et al., 1998). What the present study has shown is that the use of the "Let's Play With . . ." software (where there is guided practice with a prompt) makes acquisition of new, complex discriminations possible.

ACKNOWLEDGMENTS

This research was supported by the Spanish MEC Grant PB98-0576, and the Andalucian Government PAI (CTS-361). The authors thank Dr. Ricardo Pellon and Dr. Marc Richelle for reading the manuscript.

REFERENCES

Alcalde, C. (1996). *Conceptualización numerica en niños deficientes mediante un programa de control de estimulos* [Stimulus Control and acquisition of number of concepts with mentally handicapped children]. Unpublished doctoral dissertation, Department of Psychology, University of Cadiz, Cadiz, Spain.

Alcalde, C., & Marchena, E. (1996). *Prueba de Conceptos Basicos (PFC)* [Basic Concepts Figure Test (BCFT)]. Cadiz, Spain: Department of Psychology, University of Cadiz.

Alcalde, C., Navarro, J. I., Marchena, E., & Ruiz, G. (1998). Acquisition of basic concepts by mentally handicapped children with a computer assisted learning approach. *Psychological Reports, 82,* 1051–1056.

Anderson, J. R. (1991). The adaptative nature of human categorization. *Psychological Review, 98,* 409–429.

Bailet, J., & Weippert, H. (1992). Using computers to improve the language competence and attending behaviour of deaf children. *Journal of Computer Assisted Learning, 2,* 118–127.

Cooper, J. O., Heron, T. E., & Heward, W. L. (1987). *Applied behavior analysis.* Columbus, OH: Merrill.

Danforth, J. S., Chase, P. N., Dolan, M., & Joyce, J. H. (1990). The establishment of stimulus control by instruction and by differential reinforcement. *Journal of the Experimental Analysis of Behavior, 54,* 97–112.

Domjan, M., & Burkhard, B. (1986). *The principles of learning & behavior.* Monterey, CA: Brooks/Cole.

Dube, W. V. (1991). Computer software for stimulus control research with Macintosh computers. *Experimental Analysis of Human Behavior Bulletin, 9,* 28–30.

Dube, W. V., & McIlvane, W. J. (1989). Microcomputer-based implementation of stimulus control technology with mentally retarded individuals. *International Journal of Rehabilitation Research, 12,* 226–227.

Ferretti, R. P. (1993). Interactive multimedia research question: Results from DELPHI study. *Journal of Special Education Technology, 12*(2), 108–117.

Harrison, C., Hay, D., Pierson, A., & Burton, J. (1992). Computer literacy skills among school students and employees in industry. *Journal of Computer Assisted Learning, 4,* 194–205.

Kennedy, H. G. (1994). Manipulating antecedent conditions to alter the stimulus control of problem behavior. *Journal of Applied Behavior Analysis, 1,* 161–170.

Klein, P., & Nir Gal, O. (1992). Effects of computerized mediation of analogical thinking in kindergarten. *Journal of Computer Assisted Learning, 4,* 244–255.

Lipkens, R., Hayes, S. C., & Hayes, L. J. (1993). Longitudinal study of the development of derived relations in an infant. *Journal of Experimental Child Psychology, 56,* 201–239.

Martin, G., & Pear, J. (1983). *Behavior modification: What it is and how to do it.* Englewood Cliffs, NJ: Prentice Hall.

Murray, D. (1992). IT capability in primary schools—A case of something lost in the translation. *Journal of Computer Assisted Learning, 2,* 96–103.

Pilgrim, C., Jackson, J., & Galizio, M. (2000). Acquisition of arbitrary conditional discriminations by young normally developing children. *Journal of the Experimental Analysis of Behavior, 73,* 177–193.

Saunders, K. J., & Spradlin, J. E. (1989). Conditional discrimination in mentally retarded adults. The effect of training the component simple discrimination. *Journal of the Experimental Analysis of Behavior, 52,* 1–12.

Schreibman, L. (1975). Effects of within-stimulus and extra-stimulus prompting on discrimination learning in autistic children. *Journal of Applied Behavior Analysis, 8,* 91–112.

Skinner, M. E. (1978). Using fading to remediate number reversals. *The Directive Teacher, 1*(a), 10–15.

Snell, M. E. (1983). Implementing and monitoring the IEP: Intervention strategies. In M. E. Snell (Ed.), *Systematic instruction of the moderately and severely handicapped* (2nd ed., pp. 113–145). Columbus, OH: Charles E. Merril.

Thomas, R. M. (Ed.) (1990). *The encyclopedia of human development and studies*. London: Pergamon.

Wolery, M., Bailey, D. B., & Sugai, G. M. (1988). *Effective teaching: Principles and procedures of applied behavior analysis with exceptional students.* Boston: Allyn & Bacon.