JOURNAL OF APPLIED BEHAVIOR ANALYSIS 2004, **37,** 67–71 NUMBER 1 (SPRING 2004)

APPLICATIONS OF COMPUTER-BASED INSTRUCTION: USING SPECIALIZED SOFTWARE TO AID LETTER-NAME AND LETTER-SOUND RECOGNITION

JAMES E. CONNELL AND JOSEPH C. WITT

LOUISIANA STATE UNIVERSITY

We evaluated computerized training and testing programs with children who were having difficulties learning prereading skills. The programs were derived from equivalence research and were written in authoring software designed for educators. After learning to match uppercase and lowercase printed letters to the corresponding letter names (Tasks 1 and 2), the children matched the letters to one another (Tasks 4 and 5). Then, after learning to match uppercase letters to sounds (Task 3), they also matched lowercase letters to sounds (Task 6) and matched printed to spoken words (Tasks 7 and 8). The results recommend equivalence-based protocols and user-friendly software in further development of prereading instruction.

DESCRIPTORS: computer-based instruction, letter-sound correspondences, matching to sample, stimulus equivalence, children

Grounded in laboratory research on stimulus equivalence (e.g., Sidman, 1971), applied studies have verified the potential of using computers to teach beginning reading skills (e.g., Stromer, Mackay, Howell, McVay, & Flusser, 1996). To extend that research, we sought to demonstrate the effectiveness of user-friendly software to teach prereading skills—relations among letter names and sounds—to 2 kindergarten children.

We first evaluated whether teaching the children to match uppercase and lowercase letters to their letter names (Tasks 1 and 2) would enable them to match uppercase and lowercase letters to one another (Tasks 4 and 5). Positive outcomes on Tasks 4 and 5 would replicate past research on the formation of stimulus equivalence classes (e.g., Sidman, 1971). The children also learned to match the uppercase letters to letter sounds (Task 3). Would they then match lowercase letters to sounds (Task 6)? If so, it would demonstrate expansion of the classes (Lane & Critchfield, 1998). Finally, would the children identify printed to spoken words derived from the letters and sounds (Tasks 7 and 8)? An affirmative answer would supplement the few behavioral analyses of phonics instruction (Birnie-Selwyn & Guerin, 1997; de Rose, de Souza, & Hanna, 1996; Mueller, Olmi, & Saunders, 2000; Saunders, O'Donnell, Vaidya, & Williams, 2003).

METHOD

Participants and Setting

Lyle and Dixie were 5-year-old kindergarten students, and neither of them reliably identified any letters in the alphabet. Sessions were conducted in the school library. Prior to the experiment, the students were shown how to use the mouse and click on the buttons visible on the computer screen using a software program similar to that used in the study. The experiment began after each student reliably clicked on one of three choice stimuli after the presentation of a sample stimulus, clicked on the auditory

This study was conducted in partial fulfillment of the first author's master's thesis.

For reprints and for more information regarding the computer programs or software, contact James Connell at jeconnell8@aol.com or Joseph Witt, 236 Audubon Hall, Louisiana State University, Baton Rouge, Louisiana 70803.

sample stimulus replay button, and navigated through the introduction (e.g., friendly visual and auditory welcome and brief auditory and visual directions) and conclusion of the program.

Computer Programs and Apparatus

We used ToolBook Instructor 7® (1999) software to design one test and three training programs. This user-friendly software is designed for creating interactive instructional programs, and it has a substantial presence in business and education. The programs involved eight matching-to-sample tasks that were written to a CD and installed on a desktop computer. Choice responses (a mouse click) were recorded to a log file and saved to the computer hard drive. The auditory sample stimuli were spoken letter names or sounds (male voice) presented via external speakers as the choice stimuli appeared. Visual samples were uppercase and lowercase letters (38-point Arial) that appeared in the center on the left side of the computer screen. When samples were auditory, the left side of the screen contained a speaker icon that, if depressed, replayed the sample stimulus. The choice stimuli were three uppercase or lowercase letters or words (38-point Arial) that appeared in a column on the right side of the screen. The spoken words "correct" or "incorrect" (male voice) followed choice responses. Reliability of the computer programs was evaluated through direct observation to ensure that the electronic recordings were accurate. The computer and the human recording of responses matched 100%.

Experimental Design and Procedure

A within-subject repeated test-train-test design was used. Testing and training conditions also occurred at different times across students, thus incorporating features of a multiple baseline design. Critical data were gathered during an eight-task test program. The program served as a pretest and posttest for performances directly trained (Tasks 1, 2, and 3) and performances only tested but derived from training (Tasks, 4, 5, 6, 7, and 8). We expected highly accurate performances on Tasks 4 and 5 only after a student had learned Tasks 1 and 2, and accurate performances on Tasks 6, 7, and 8 only after Task 3 had also been trained.

Testing before training. Before training, Lyle was exposed to the test program nine times and Dixie five times before stable responding was established. We assessed performances on eight tasks: (1) matching uppercase letters (J, E, D) to spoken letter names ("J," "E," "D"), (2) matching lowercase letters (j, e, d) to spoken letter names, (3) matching uppercase letters (J, E, D) to spoken letter sounds, (4) matching uppercase letters (J, E, D) to lowercase letters (j, e, d), (5) matching lowercase letters (j, e, d) to uppercase letters (J, E, D), (6) matching lowercase letters (j, e, d) to spoken letter sounds, and (7) selecting the uppercase (JED) and (8) lowercase (jed) words to the spoken word "Jed." The choice stimuli for Tasks 1 to 6 were uppercase (J, E, D) or lowercase letters (j, e, d). The choice stimuli for Tasks 7 and 8 were uppercase words (JED, BIG, RAN) or lowercase words (jed, big, ran). Testing involved 20 trials, three trials each on Tasks 1 to 6 and one trial each on Tasks 7 and 8. The students took about 4 min to complete the program. No differential consequences (computerized or otherwise) occurred during testing.

Training. Three training programs targeted Tasks 1 to 3 (as in the pretest): Task 1 required matching the printed uppercase letters to their respective spoken letter names. Task 2 required matching the lowercase letters to their respective spoken letter names. Task 3 required matching the uppercase letters to their respective spoken letter sounds. Each program involved 30 trials (10 for each of three letters) presented unsystematically.

Poker chips were delivered on a variable-ratio 5 schedule for correct responses and were exchanged for small tangible items (e.g., small toys and candy) following a session. The training criterion was the same for each program: two consecutive sessions with 100% accuracy.

Testing after training Task 1 (Dixie only). The eight-task test program described above was presented after Dixie received extended training on Task 1 (her pretest accuracy was 100%). We wanted to verify Task 1 under test conditions and the absence of accurate performances on Tasks 2 to 8. The program was administered five times to establish stable performance.

Testing after training Tasks 1 and 2. The test program was presented after Lyle had met the training criterion for Task 1 and then Task 2 and after Dixie had met the criterion for Task 2. We wanted to verify Tasks 1 and 2 under test conditions, improvement on Tasks 4 and 5 (via the formation of equivalence classes), and the absence of accurate performances on Tasks 3, 6, 7, and 8. The test program was administered five times to Lyle to establish stable performance; Dixie was exposed to the test program five times for Tasks 4 and 5 and six times for Tasks 6 to 8.

Testing after training Tasks 1, 2, and 3. The test program was presented after criterion had been met on the training program for Task 3. Lyle's posttest involved nine test sessions; Dixie's involved five sessions. We wanted to verify highly accurate performances on the trained Tasks 1, 2, and 3 and on Tasks 4 to 8 that were never directly trained. Performances on Task 6 may improve under this test because training Task 3 may have added letter sounds to the equivalence classes already established between uppercase and lowercase letters. If the classes now involve letter sounds, performances on Tasks 7 and 8 may also improve.

RESULTS AND DISCUSSION

Figure 1 illustrates accuracy scores on Tasks 1 to 8 for Lyle and Dixie during testing. (Note that the absence of a bar reflects 0% correct.) Before training, Lyle's test scores (black bars) on the tasks to be trained were 41%, 55%, and 41% on Tasks 1, 2, and 3, respectively; scores were 63%, 30%, 44%, 0%, and 0% on untrained Tasks 4, 5, 6, 7, and 8, respectively. Lyle then met the training criterion on Task 1 in 11 sessions and on Task 2 in five sessions (training data are not shown). After training Tasks 1 and 2, Lyle's scores (checked bars) stayed high on Tasks 1 and 2 (100%), stayed low on Task 3 (27%), improved on Tasks 4 and 5 (100% and 93%, respectively), and stayed low on Tasks 6, 7, and 8 (60%, 0%, and 0%, respectively). After training Task 3 (criterion met in 12 sessions), all of Lyle's test scores (spotted bars) were high (96% to 100%).

Before training, Dixie's test scores (black bars) were 100%, 47%, and 13% on Tasks 1, 2, and 3, respectively, and ranged from 47% to 0% on Tasks 4 to 8. After extended training on Task 1 (nine sessions), Dixie's scores (gray bars) stayed high on Task 1 (100%) but were relatively low on Tasks 2 to 8 (73% to 0%). After training Task 2 (criterion met in three sessions), Dixie's scores (checked bars) on Tasks 1, 2, 4, and 5 were 100%; her scores on Tasks 3, 6, 7, and 8 were 33%, 39%, 50%, and 0%, respectively. After training Task 3 (criterion met in nine sessions), Dixie's scores (spotted bars) were perfect on all tasks.

The present study replicates prior research demonstrating the formation of classes of equivalent stimuli in reading (e.g., Sidman, 1971): After learning to match uppercase and lowercase letters to their letter names (Tasks 1 and 2), Lyle and Dixie matched uppercase and lowercase letters to one another (Tasks 4 and 5) without additional training, verifying class formation. To extend

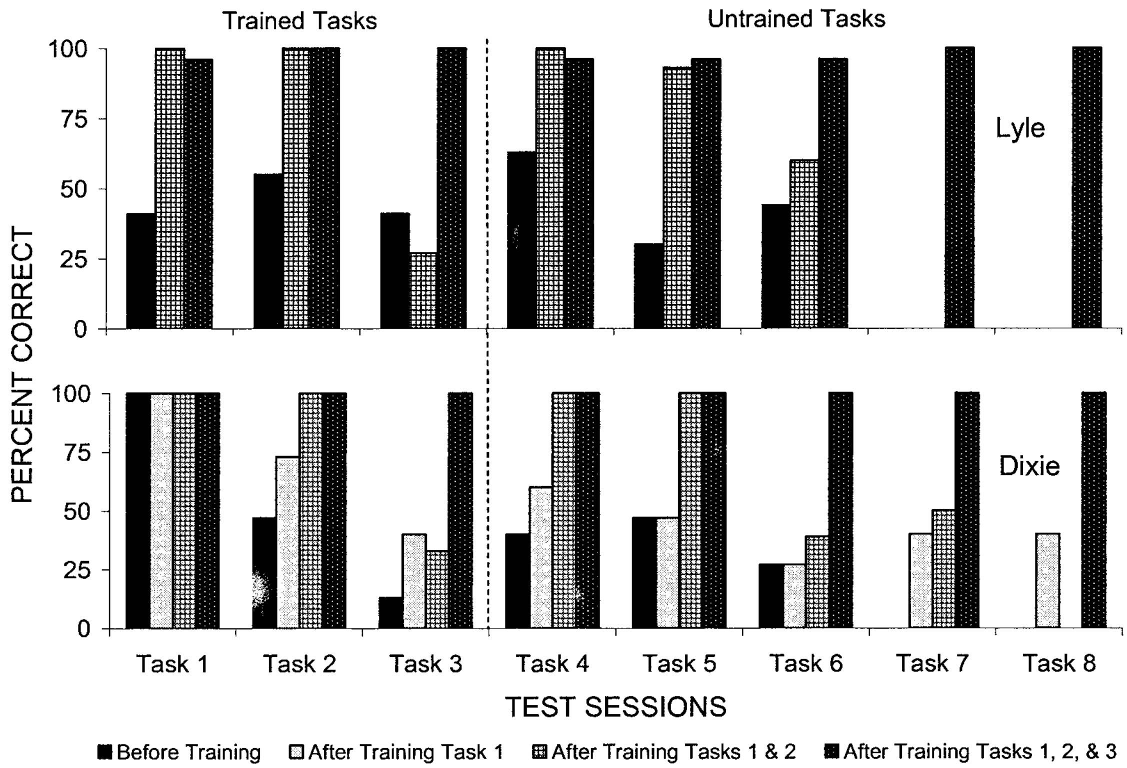

Figure 1. Percentages correct for Lyle (top panel) and Dixie (bottom panel) on Tasks 1 to 3 that were used during training and on Tasks 4 to 8 that were only tested. For all eight tasks, black bars (pretest) show results before training; gray bars (Dixie only) show results after extended training on Task 1; checked bars show results after training Tasks 1 and 2; and spotted bars show results after training Tasks 1, 2, and 3 (absence of a bar reflects 0% correct).

prior work and verify class expansion (e.g., Lane & Critchfield, 1998), the children learned to match uppercase letters to letter sounds; this enabled them to match lowercase letters to sounds (Task 6) and select words printed in uppercase and lowercase letters corresponding to spoken words (Tasks 7 and 8). These outcomes support the view that use of computerized methods derived from stimulus equivalence and related areas of research can advance language arts instruction in general (e.g., Stromer et al., 1996) and phonics instruction in particular (Birnie-Selwyn & Guerin, 1997; de Rose et al., 1996; Mueller et al., 2000).

Directions for future research could expand the computerized assessments of phoneme segmentation and blending to better understand the stimuli that control responding to printed words JED and jed in response to the spoken word "Jed" (Tasks 7 and 8) (e.g., Mueller et al., 2000). We acknowledge, for example, that Tasks 7 and 8 did not require conditional discriminative control, which limits the external validity of these emergent performances. Use of larger stimulus sets could also help to resolve shortcomings of the design of the present preliminary analysis. Additional investigations might also restructure the training programs to broaden the learning outcomes to include oral reading and spelling skills that may be generative in nature (e.g., Birnie-Selwyn & Guerin, 1997; de Rose et al., 1996; Mueller et al.). Finally, the software used in this experiment, although user-friendly, required some practice. Future endeavors could explore the development of methods for training teachers to use the software. The results of the present study are promising and suggest that specialized software can aid teachers and others (e.g., parents) in developing individualized programs to address deficits in prereading skills.

REFERENCES

Birnie-Selwyn, B., & Guerin, B. (1997). Teaching children to spell: Decreasing consonant cluster errors by eliminating selective stimulus control. *Journal of Applied Behavior Analysis, 30,* 69–91.

de Rose, J. C., de Souza, D. G., & Hanna, E. S. (1996). Teaching reading and spelling: Exclusion and stimulus equivalence. *Journal of Applied Behavior Analysis, 29,* 451–469.

Lane, S. D., & Critchfield, T. S. (1998). Classification of vowels and consonants by individuals with moderate mental retardation: Development of arbitrary relations via match-to-sample training with compound stimuli. *Journal of Applied Behavior Analysis, 31,* 21–41.

Mueller, M. M., Olmi, D. J., & Saunders, K. J. (2000). Recombinative generalization of within-syllable units in prereading children. *Journal of Applied Behavior Analysis, 33,* 515–531.

Saunders, K. J., O'Donnell, J., Vaidya, M., & Williams, D. C. (2003). Recombinative generalization of within-syllable units in nonreading adults with mental retardation. *Journal of Applied Behavior Analysis, 36,* 95–99.

Sidman, M. (1971). Reading and auditory-visual equivalences. *Journal of Speech and Hearing Research, 14,* 5–13.

Stromer, R., Mackay, H. A., Howell, S. R., McVay, A. A., & Flusser, D. (1996). Teaching computer-based spelling to individuals with developmental and hearing disabilities: Transfer of stimulus control to writing tasks. *Journal of Applied Behavior Analysis, 29,* 25–42.

ToolBook Instructor (Version 7). (1999). [Computer software]. Bellevue, WA: Click2Learn, Inc.

Received August 29, 2002
Final acceptance November 11, 2003
Action Editor, Robert Stromer