JOURNAL OF APPLIED BEHAVIOR ANALYSIS 1996, 29, 25–42 NUMBER 1 (SPRING 1996)

TEACHING COMPUTER-BASED SPELLING TO INDIVIDUALS WITH DEVELOPMENTAL AND HEARING DISABILITIES: TRANSFER OF STIMULUS CONTROL TO WRITING TASKS

ROBERT STROMER, HARRY A. MACKAY,
SARAH R. HOWELL, AND ALISON A. MCVAY

EUNICE KENNEDY SHRIVER CENTER AND NORTHEASTERN UNIVERSITY

AND

DEBBIE FLUSSER

THE LEARNING CENTER, PGHS, INC.

Computer-based instruction may yield widely useful handwritten spelling. Illustrative cases involved individuals with mental retardation and hearing impairments. The participant in Study 1 matched computer pictures and printed words to one another but did not spell the words to pictures. Spelling was then taught using a computerized procedure. In general, increases in the accuracy of computer spelling were accompanied by improvements in written spelling to pictures. Study 2 extended these results with a 2nd participant. After initial training, spelling improved in the context of a retrieval task in which the participant (a) wrote a list of the names of objects displayed on a table, (b) selected the objects from a shelf, and (c) returned the objects to the table. Nearly perfect accuracy scores declined on some retrieval trials conducted without a list, suggesting that the list may have served a mediating function during retrieval. Transfer of stimulus control of computer-based teaching to the retrieval task may have been attributable to the existence of stimulus classes involving pictures, objects, and printed words.

DESCRIPTORS: communication, spelling, matching to sample, transfer of stimulus control, multiple handicaps

---

Manual signing is often the modality of choice for teaching communication skills to individuals with mental retardation and hearing deficits. There are also compelling reasons for supplementing signing skills by teaching a means of communication that permits meaningful interaction with people who do not sign. This might be done using picture-, symbol-, or word-selection procedures. Moreover, even a modest writing repertoire might serve as the basis for establishing functional communication skills. Teaching written communication is justified because doing so could (a) minimize the prejudice and stigma associated with the use of forms of communication alien to the hearing community, (b) help to maximize opportunities for independent functioning (McNaughton & Tawney, 1993; Vanderheiden & Lloyd, 1986; cf. Romski, Sevcik, & Joyner, 1984), and (c) facilitate generalization by bringing the person in contact with reinforcers difficult to obtain by unconventional forms of communication (cf. D. Baer & Wolf, 1970). Such general concerns also justify the development of effective and efficient ways of teaching spelling.

This research was supported by the National Institute of Child Health and Human Development (Grant HD25995) and the Massachusetts Department of Mental Retardation (Contract 100220023SC). Portions of the report are based on a Master's thesis by Sarah Howell and a prethesis project by Debbie Flusser, each submitted to the Department of Psychology, Northeastern University. We are grateful to Anne Kupfer for her support and encouragement during the project, and to Krista Wilkinson for helpful comments on the manuscript.

Address correspondence to Robert Stromer, Behavioral Sciences Division, Eunice Kennedy Shriver Center, 200 Trapelo Road, Waltham, Massachusetts 02254 (E-mail: RStromer@Shriver.org).

Computerized procedures may establish spelling in hearing individuals with mental retardation (Dube, McDonald, McIlvane, & Mackay, 1991; Stromer & Mackay, 1992a, 1992b, 1993). For example, Stromer and Mackay (1992a) tested such participants and found that they matched pictures and printed words to one another and to dictated words. They did not, however, spell the words to pictures and dictation. The computer spelling task, called anagram spelling, involved selecting letters displayed on the computer screen. To illustrate, if the picture of a cup as the sample stimulus was shown, touching *c*, *u*, and *p* from a choice pool of letters completed the trial. We established anagram spelling performances with a delayed word-construction task. This task was like anagram spelling, except the sample was a printed word that was removed from the screen before the letter selection began. An additional finding was that 1 participant's handwritten spelling improved after anagram spelling had been established, a finding with obvious practical implications (cf. Stevens, Blackhurst, & Slaton, 1991; Stromer & Mackay, 1993).

The current studies sought to extend the findings of Stromer and Mackay (1992a) by establishing spelling performances in 2 participants with both developmental and hearing deficits. They communicated using a few manual signs and picture books; they could spell a few words in writing but rarely did so to communicate. Studies 1 and 2 systematically examined whether procedures that led to anagram spelling also yielded written spelling. Study 2 also examined whether computer-based teaching would lead to the writing of simple lists and the use of those lists in a retrieval task. Study 2, therefore, addressed crucial concerns about the generality of computer-based teaching across settings (see also Schlosser & Braun, 1994; Stokes & Baer, 1977). Taken together, the studies complemented previous work using stimulus control concepts and procedures to develop rudimentary reading and writing repertoires (e.g., Browder & Lalli, 1991; Singh & Singh, 1986; Stromer, Mackay, & Stoddard, 1992). The methods may hold special promise for establishing supplementary communication skills (Brady & Saunders, 1991; Remington, 1994).

GENERAL METHOD

Participants and Setting

Claire (aged 49) and Mike (aged 21) had mental retardation and profound hearing losses; Mike was also diagnosed with autism. Claire's and Mike's mental age equivalent scores on the Leiter International Performance Scale were 6 years 7 months and 7 years 9 months, respectively. Claire had previously learned to reproduce arbitrary letter strings and to spell nine words (e.g., *car* and *shoe*) using an earlier version of the present procedures. Mike was familiar with the apparatus because of an assessment that used matching-to-sample procedures and identity constructions of strings of up to six upper case letters (Dube et al., 1991). Sessions were held three to six times per week in a quiet room and lasted approximately 10 min for Claire and 20 min for Mike. A trainer monitored all computer tasks.

Apparatus

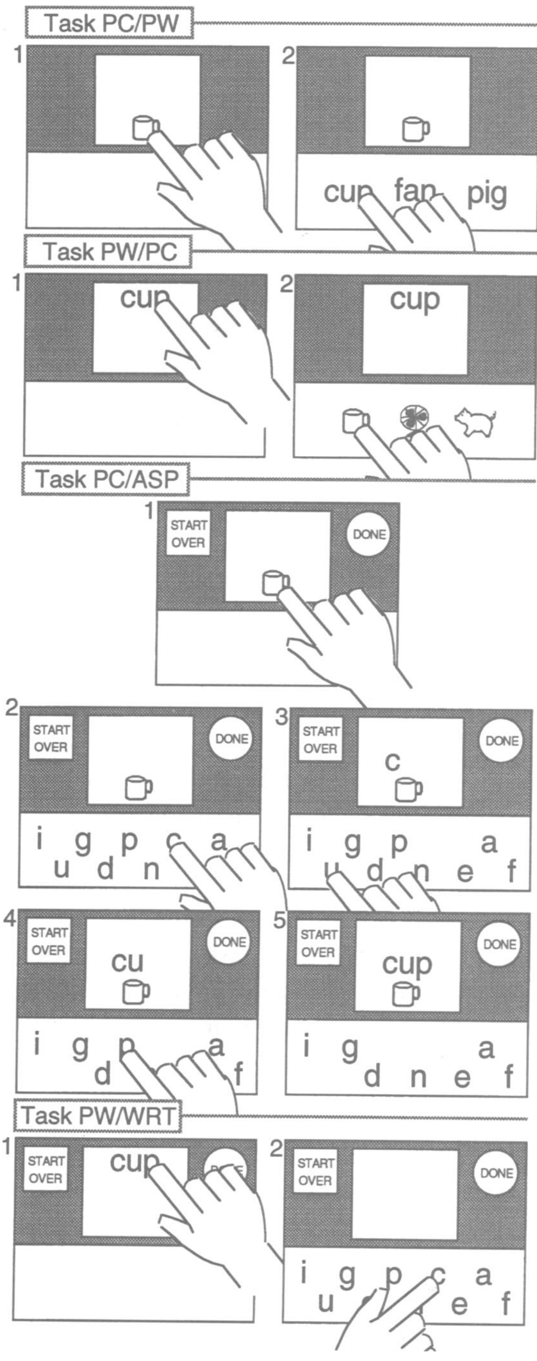
During certain tasks, a Macintosh® computer with a touch-sensitive screen presented stimuli and recorded data. Printed-word and picture sample stimuli appeared in the upper and lower parts of the computer display, respectively (Figure 1). Words were constructed letter by letter in the middle of the sample area. Comparison stimuli were presented in the lower part of the display and were either three pictures, three printed words, or 10 letters (lower case). The locations where samples and comparisons appeared were also response "keys." Two other keys, always labeled START OVER and DONE, were located in the upper corners of the display.

General Procedures

This section describes the five computer-based tasks used in both studies. General features of the tabletop tasks used in Study 2 are also described. The specific order in which the tasks were presented to participants is described later.

Matching pictures (PC) and printed words (PW). The panels in the top row of Figure 1 show a trial involving selection of a printed-word comparison given a picture sample (PC/PW); the second row shows a trial requiring selection of a picture given a printed word (PW/PC). Trials began with a sample, and a touch to it produced three comparisons. Touching a correct comparison always produced a flashing computer display and a 3-s intertrial interval. Claire was also given a penny for each correct trial. Mike received a token after each correct trial and exchanged them for soda at the end of the session. Touching an incorrect comparison began the intertrial interval. The particular sample and the positions of comparisons varied unsystematically from trial to trial. Variations of these trials were used during initial training or during baseline preparation.

Anagram spelling (ASP) to pictures (PC). The third, fourth, and fifth rows of panels in Figure 1 depict anagram spelling to a picture sample (PC/ASP). The task was to



→

Figure 1. The panels represent the four computer tasks used in Studies 1 and 2. The top pair of panels illustrate the PC/PW task, matching printed-word comparisons to picture samples; the second pair of panels show the PW/PC task, matching pictures to printed words. The middle panels show PC/ASP, anagram spelling to pictures. PW/CNS is shown at the bottom and involved delayed word constructions after printed words were removed from the screen. Like PC/ASP, PC/WRT (not shown) involved picture samples, but the response was to write the word.

touch letters in the choice pool that spelled the word corresponding to the picture sample. Ten letters appeared in the choice pool on all trials. Three or four of the letters spelled the correct word (e.g., *cup, flag*); the remaining letters were selected randomly by the computer. For example, with the picture of a cup as the sample, a touch to the letter *c* moved it from the choice pool to the construction area; subsequent touches to the letters *u* and then *p* moved them to the construction area. A touch to the DONE key then ended the trial and recorded the data. In this example, the construction was coded "correct" by the computer. An "incorrect" trial was coded if the DONE button was touched when no letters were in the construction area or when the construction was inconsistent with English conventions. The consequences for correct and incorrect trials were the same as in the matching tasks (PC/PW and PW/PC). At any time during the trial, a touch to the START OVER key removed all letters from the construction area, replaced them in the choice pool, and began the trial again, thus providing a correction procedure. The START OVER key was effective until the DONE key was touched to end the trial. The use of these buttons was demonstrated to each participant.

Delayed word construction (CNS) to printed words (PW). The bottom row of Figure 1 shows the PW/CNS task, which differed from PC/ASP because it involved constructing words to printed word samples rather than to pictures. Pretraining for this basic repertoire used a procedure in which the printed word remained visible in the sample area until the word construction was completed (not shown in Figure 1). Then, in the delayed procedure illustrated in Figure 1, a touch to the sample word removed it from the screen and immediately (0-s delay) presented the choice letters. The use of the delay ensured appropriate stimulus control of word constructions (e.g., delayed construction of a printed word verified control by all letters of the sample word). The participant needed to discriminate each letter in the word and their order to be correct. The consequences for correct and incorrect trials and the operation of the START OVER and DONE buttons were as in the PC/ASP task (except as described later).

Writing words (WRT) to pictures (PC). PC/WRT (not shown in Figure 1) involved writing (in pencil) the name of picture samples on a blank slip of paper after touching the sample. After a correct trial, the experimenter pressed J on the keyboard and pressed K after an error. These key presses activated the consequences (described earlier) scheduled for that trial.

Tabletop tasks. Study 2 involved several trainer-delivered tabletop tasks. The stimuli were enlarged photocopies of the computer pictures mounted on index cards, words printed (lower case) by hand on index cards, and objects. Trials began with the three comparisons arranged in a row. The sample was then placed in a flat container located just above the comparisons in the center of the table. Placing the correct comparison into the container resulted in reinforcement, and incorrect selections did not. The sample and the positions of comparisons varied across trials. In addition, sometimes the comparisons were three index cards that each displayed two printed words. These trials were arranged to encourage discriminative control by each of the words. For example, if the correct comparison was a card with the words *pig/cup* (top/bottom) printed on it, the two incorrect comparisons were *pig/fan* and *cup/fan.*

Reliability. All handwritten and tabletop trials were scored by independent observers (correct and incorrect responses). The experimenter's presentation of stimuli and use of reinforcement were also assessed. Interobserver agreement for scoring and task presentation averaged 98% and 97%, respectively.

Study 1

Preliminary study with Claire encouraged further use of the computer-based procedures to establish anagram and written spelling to pictures. In this systematic study, Stromer and Mackay's (1992a) procedures were refined by incorporating the START OVER and DONE functions described earlier.

Procedures and Results

The five tasks described earlier were used with four stimulus sets. Most sessions involved tasks in the following series of seven six-trial blocks: (a) anagram spelling to pictures (PC/ASP); (b) matching printed words to pictures (PC/PW); (c) matching pictures to printed words (PW/PC); (d) anagram spelling to pictures (PC/ASP); (e) delayed word construction to printed words (PW/CNS), the primary training task; (f) anagram spelling to pictures (PC/ASP); and (g) writing the names of the pictures (PC/WRT). Exposure to PW/CNS within a session continued until six of six trials were correct (accuracy scores of 6) or until 18 trials occurred. Sessions with each stimulus set were usually repeated until a score of at least 5 occurred on each of the seven tasks for three or more consecutive sessions.

Figure 2 shows Claire's results. Each bar reflects the number of correct trials out of six; for delayed word construction to printed words (PW/CNS, third row from bottom), bars show the number of correct trials in the first six presented.

Set 1 (cup, fan, pig). Sessions 1 to 10 established anagram spelling with Set 1. During Sessions 1 to 6, the initial six trials of anagram spelling (PC/ASP) were not given. These sessions were added in Session 7 to provide an assessment of spelling at the beginning of successive sessions. As shown in successive rows from the top, accuracy scores for matching to sample (PC/PW and PW/PC) were almost always perfect. Anagram spelling (PC/ASP) followed, and scores ranged from 2 to 6 correct during Sessions 1 to 6. During delayed construction of printed words (PW/CNS), Claire usually scored 5 or better for the first six trials, but scored only 4 during Session 3. In subsequent anagram (PC/ASP) and written spelling (PC/WRT) tasks, scores were always 5 or better; the exceptions were scores of 3 and 4 during Session 3, the same session that contained the lowest score for delayed word construction. Sessions 7 to 10 each began with anagram spelling (PC/ASP), and Claire's scores were nearly perfect for all tasks.

Set 2 (bus, key, saw). Performances with Set 2 were established in Sessions 11 to 22 using the full seven-task protocol. Scores during the initial PC/ASP task improved gradually and were consistently at least 5 by Session 18. Scores for PC/PW and PW/PC were always high. Scores during the second exposures to PC/ASP improved more rapidly than the initial ones, with most scores being at least 5 by Session 14. As with Set 1, scores for PW/CNS were generally high, as were those for the third exposure to PC/ASP and for PC/WRT.

Set 3 (hand, star, vest). During Sessions 23 to 26, Claire's patterns of performance differed from those with previous sets. Performance on PC/PW improved rapidly and was almost perfect on PW/PC. However, Claire repeatedly scored 2 on PC/ASP, PW/CNS, and PC/WRT, correctly spelling and constructing only the word *star.* Error analysis revealed that Claire almost always touched the correct initial letter of *hand* and *vest,* then simply touched the DONE key to end the trial. Likewise, on PC/WRT, Claire only wrote the initial letters of these words. High scores on these tasks were then quickly achieved after the correction procedure was changed for PW/CNS in Session 27. Now, the START OVER and DONE keys appeared only *after* the number of letters required to spell a word had been selected, rather than at the start of a trial; the printed-word sample was also added to the display (a kind of "spell check" prompt). Touching

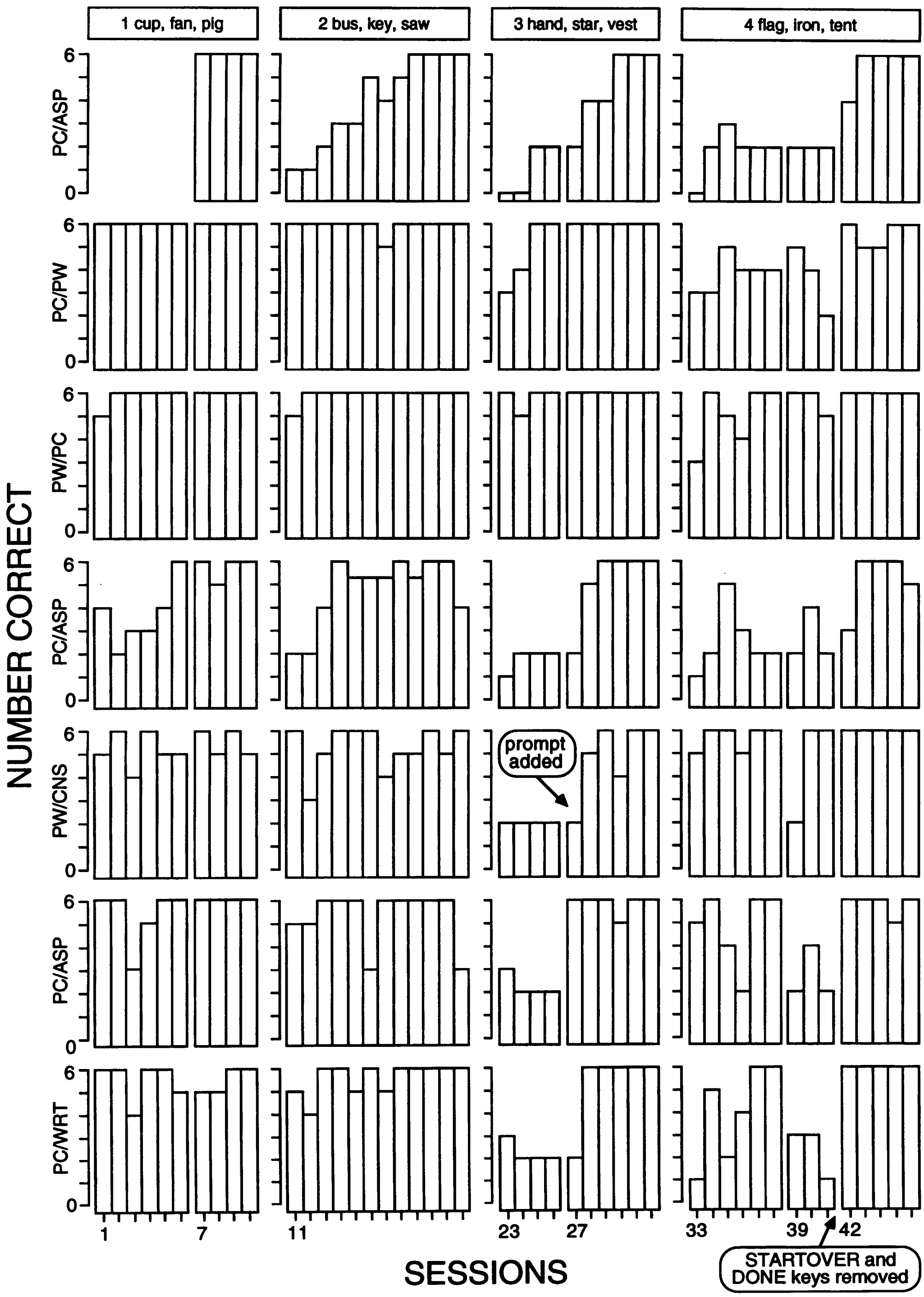


Figure 2. Claire's data for Study 1: Each bar represents the number of correct trials out of six for a particular task. The tasks used are listed along the ordinate in the order in which they were given during each session. (The absence of a bar means that task did not occur.) The columns of bars are arranged in groups of sessions devoted to each of four sets of stimuli (noted across the top of the figure).

the START OVER key then removed the sample word and returned all letters to the choice pool. All other consequences and functions of the START OVER and DONE keys were as in PC/ASP.

Set 4 (flag, iron, tent). In Sessions 33 to 38, we continued to use the modified correction procedure introduced during training with Set 3. Sessions 39 to 41 were the same and occurred after Claire had been on vacation for 2 weeks. In most sessions, scores were 2 on the initial PC/ASP task, higher but somewhat variable on PC/PW and PW/PC, and then often 2 on PC/ASP again. Scores were typically high on PW/CNS and were variable on PC/ASP and PC/WRT, but more scores of at least 5 occurred. During Sessions 42 to 46, the START OVER and DONE keys were removed and most scores were high.

Discussion

Claire's data extend Stromer and Mackay (1992a) by showing that computer-based procedures may be used to establish anagram and written spelling performances in an individual with both developmental and hearing disabilities. However, the relationship between anagram and written spelling is complex, requiring further analysis. For example, the bottom of Figure 2 shows that late in each session, high accuracy in anagram spelling frequently was followed by high accuracy in written spelling. In contrast, when anagram spelling was poor, the written spelling that followed was also poor (Sets 2 and 3). This suggestion of close correlation between the performances is not supported when the anagram spelling data from the start of sessions (top row) is also considered; inaccurate performance early in a session was frequently followed later in the same session by improved anagram and written spelling. The improved performance in the anagram task, however, often was not maintained in the next session. Several sessions were required to ensure consistent accuracy in all performances with each set of stimuli. Further analyses, including tests of written performance at the start of sessions, for example, will help to clarify the relationship of the anagram and written spelling performances.

We have regarded the delayed word construction task as the primary procedure for teaching spelling. The importance of this task is suggested by the data in Rows 4 to 6 of Figure 2. Performance on the retests of anagram spelling (Row 6) was only rarely accurate if errors occurred on the word construction task (Row 5). However, considerable improvement in anagram spelling (compare Rows 4 and 6) often immediately followed accurate delayed word construction. It is possible, of course, that other aspects of the protocol (e.g., the order in which the tasks were presented) may have contributed to the effects observed. The role of such factors awaits examination in research using similar protocols for assessing and teaching spelling, writing, and related performances.

Further work is needed to clarify use of the START OVER and DONE features of delayed word construction (PW/CNS). Claire's data suggested a lack of desired stimulus control by the START OVER and DONE keys. Difficulties arose when the longer and perhaps more difficult words in Set 3 were introduced and the contingencies were favorable for ending (DONE) rather than repeating (START OVER) a trial. The added "spell check" prompt solved the problem temporarily. However, on the next set of words, Claire sometimes consistently touched the DONE key prematurely during anagram spelling (PC/ASP), even though delayed word construction (PW/CNS) was accurate. We opted for removal of the START OVER and DONE keys to resolve this problem; unfortunately, Claire was unavailable to help us in the further analysis needed to reach a more satisfying solution.

Study 2

With Mike, we sought to replicate Claire's positive outcomes. We also examined whether the computer-based performances would give rise to the production and use of written lists.

Phase 1: Preliminary Procedures and Results

This preliminary phase was designed to ensure that performances prerequisite for further teaching and testing in Phase 2 were in Mike's repertoire. Computer tasks and all general methods were the same as for Claire. Tabletop tasks also used these same general procedures. Table 1 outlines the tasks used (but not necessarily the order in which they occurred) during the 83 sessions of Phase 1. The following summarizes the procedures and results.

Computer tasks (Sessions 1–29). As with Claire, Mike matched the printed words *cup, fan,* and *pig* and computer pictures to one another (PC/PW and PW/PC) from the start of the experiment. Mike did not spell the words to pictures, either by construction or writing (PC/ASP and PC/WRT, respectively). We used delayed word construction (PW/CNS) to establish the basis for anagram spelling. Initially, Mike attempted to draw the pictures displayed on the computer rather than write their names. Writing was achieved by using a correction procedure in which drawing was interrupted and writing was prompted by displaying the word printed on an index card, then removing the card when Mike began to write.

Tabletop tasks (Sessions 30–41). During these sessions, we wanted to (a) establish relations among computer and tabletop tasks and (b) ensure stimulus control by the complex stimuli involved. Initially, Mike was familiarized with the tabletop tasks by establishing identity matching with the pictures, words, and objects (1, 2, and 3 in Table 1). We then assessed whether Mike would match pictures to printed words (4), objects to printed words (5), and pictures and objects to one another (6 and 7). Two tasks also assessed whether the pictures and objects, respectively, would control written spelling (8 and 9). Mike was virtually perfect on each of these tasks. Mike also did identity matching when the samples and comparisons were two objects and two printed words (10 and 11). These performances prepared Mike for an assessment of whether the names of two objects printed on an index card controlled selections of two objects

Table 1
Outline of Preliminary Procedures Used in Study 2 (Phase 1)

Computer tasks (Sessions 1–29)
Matching printed words to pictures (PC/PW)
Matching pictures to printed words (PW/PC)
Anagram spelling to pictures (PC/ASP)
Delayed word construction to printed words (PW/CNS)
Writing words to pictures (PC/WRT)
Tabletop tasks (Sessions 30–41)
Matching pictures to pictures (1)
Matching printed words to printed words (2)
Matching objects to objects (3)
Matching pictures to printed words (4)
Matching objects to printed words (5)
Matching pictures to objects (6)
Matching objects to pictures (7)
Writing words to pictures (8)
Writing words to objects (9)
Matching objects to pairs of objects (10)
Matching printed words to pairs of printed words (11)
Matching objects to pairs of printed words (12)
Writing words to pairs of objects; selecting objects (13)
Testing delayed matching (Sessions 42–64)
Writing words to pairs of objects; selecting objects (delayed matching)
Retrieving (Sessions 65–83)
Writing words to pairs of objects; retrieving objects (RETRV)

Note. All sessions in Phase 1 involved Set 1 (*cup, fan, pig*). During Sessions 1 to 41, the order and number of tasks given in a session varied; the text summarizes the procedures and results (details are available from the first author). The computer tasks given during Sessions 1 to 29 were the same as those used with Claire in Study 1.

(12). They did. Moreover, Mike wrote the names of two sample objects perfectly before selecting the two objects from a set of comparisons (13).

Testing delayed matching (Sessions 42–64). During the delayed matching task (see Table 1), trials began with presentation of two objects. Mike then wrote the object names. Next, the sample objects were removed and the comparison objects were presented. Mike selected objects with the list displayed on the table. We then assessed Mike's matching accuracy without the list. In this no-list condition, both the objects and the list were removed from the table. In addition, the presentation of the comparison objects was delayed gradually from 0 to 10 s across sessions. Mike's accuracy on list trials was always high. On no-list trials, errors were initially frequent at delays of 4 to 10 s; scores then improved markedly in subsequent sessions.

Retrieving (Sessions 65–83). Components of the delayed matching task were the bases for the object retrieval task (see Table 1): Two sample objects were displayed on the table, and Mike wrote their names on a list. The list was placed in a hip pack, and Mike went to a shelf located in a neighboring room where the comparisons were displayed. After placing the list on the shelf, Mike picked up the objects and placed them in a bag, returned to the table, and put the objects in the container. The trainer provided the scheduled consequences, then rearranged the comparison objects on the shelf while Mike waited at the table for the next trial. In Sessions 65 to 69, the trainer accompanied Mike throughout the trial. The only assistance Mike needed were prompts to remove the list from the pack and place the list right side up on the shelf. In Sessions 70 to 83, the trainer stayed at the table; Mike's writing and object retrieval were perfect.

Phase 2: Spelling Procedures and Results

With the preceding computer and tabletop tasks established, Phase 2 examined the transfer of stimulus control among some of them. Table 2 illustrates the general plan. A multiple probe design (e.g., Horner & Baer, 1978; see also Stromer & Mackay, 1992b) was used to assess the effects of the delayed word-construction procedure (PW/CNS) on anagram spelling to pictures (PC/ASP). To overview, the computer tasks were given first during pretesting (Sessions 84–86) to assess entry matching and anagram spelling performances with each of three new sets of stimuli. We then (Sessions 87–101) assessed tabletop matching and spelling performances with tasks involving pictures, printed words, and objects. The subsequent testing and teaching conditions (Sessions 102–129) consisted of two parts. In Part 1 (e.g., Sessions 102–108), the aim was to test anagram spelling to pictures (PC/ASP), again with one of the stimulus sets (e.g., Set 2). During these sessions, anagram spelling and writing to pictures (PC/ASP+WRT) and object retrieval (RETRV) were maintained using familiar stimuli (e.g., Set 1). Sessions then continued until performance on the anagram spelling task reached criterion. Part 2 of each testing and teaching condition then used the training stimuli (e.g., Set 2) and assessed (a) anagram and written spelling to pictures at the beginning of each session and (b) written spelling and object retrieval at the end. Finally, posttesting (Sessions 130 and 131; not shown in Table 2) assessed anagram and written spelling to pictures and written spelling and object retrieval with each set of stimuli.

Pretesting (Sessions 84–86). Session 84 (at left in Figure 3) began with six review trials to maintain computer-based spelling with the Set 1 stimuli (*cup, fan, pig*); three anagram spelling trials were followed by three writing trials (PC/ASP+WRT). The next

Table 2
Procedures and Order of Tasks Used During Each Session in Study 2 (Phase 2)

Pretesting (Sessions 84–86)	
1. PC/ASP+WRT	Anagram spelling and writing to pictures (Set 1)
2. PC/ASP	Anagram spelling to pictures (Sets 2, 3, then 4)
3. PC/PW	Matching printed words to pictures (Sets 2, 3, then 4)
4. PW/PC	Matching pictures to printed words (Sets 2, 3, then 4)
5. RETRV	Writing words to pairs of objects; retrieving objects (Set 1)
(See text for summary of pretesting in Sessions 87–101)	
Testing and teaching Set 2 (Sessions 102–108)	
1. PC/ASP+WRT	Anagram spelling and writing to pictures (Set 1 in Part 1; Set 2 in Part 2)
2. PC/ASP	Anagram spelling to pictures (Set 2 in Parts 1 and 2)
3. PW/CNS	Delayed word construction to printed words (Set 2 in Parts 1 and 2)
4. PC/ASP	Anagram spelling to pictures (Set 2 in Parts 1 and 2)
5. RETRV	Writing words to pairs of objects; retrieving objects (Set 1 in Part 1; Set 2 in Part 2)
Testing and teaching Set 3 (Sessions 109–119)	
1. PC/ASP+WRT	Anagram spelling and writing to pictures (Set 2 in Part 1; Set 3 in Part 2)
2. PC/ASP	Anagram spelling to pictures (Set 3 in Parts 1 and 2)
3. PW/CNS	Delayed word construction to printed words (Set 3 in Parts 1 and 2)
4. PC/ASP	Anagram spelling to pictures (Set 3 in Parts 1 and 2)
5. RETRV	Writing words to pairs of objects; retrieving objects (Set 2 in Part 1; Set 3 in Part 2)
Testing and teaching Set 4 (Sessions 120–129)	
1. PC/ASP+WRT	Anagram spelling and writing to pictures (Set 3 in Part 1; Set 4 in Part 2)
2. PC/ASP	Anagram spelling to pictures (Set 4 in Parts 1 and 2)
3. PW/CNS	Delayed word construction to printed words (Set 4 in Parts 1 and 2)
4. PC/ASP	Anagram spelling to pictures (Set 4 in Parts 1 and 2)
5. RETRV	Writing words to pairs of objects; retrieving objects (Set 3 in Part 1; Set 4 in Part 2)
Posttesting (Sessions 130 and 131)	
1. PC/ASP+WRT	Anagram spelling and writing to pictures (Sets 1–4)
2. RETRV	Writing words to pairs of objects; retrieving objects (Sets 1–4)

Note. Each of the Sessions 87 to 95 involved only PC/ASP + WRT and RETRV with Set 1 (*cup, fan, pig*). Each of the Sessions 96 to 101 also involved the three matching tasks and Set 2 (*cow, jar, tie*), Set 3 (*bed, cat, pot*), and Set 4 (*bus, car, dog*).

three six-trial blocks assessed anagram spelling (PC/ASP), matching printed words to pictures (PC/PW), and matching pictures to printed words (PW/PC) with Set 2 (*cow, jar, tie*). Finally, in the last six-trial block, the retrieval task (RETRV) was given with Set 1. Figure 3 shows that Mike's scores were at least 5 on all tasks except anagram spelling, for which the score was 2. The series of tasks was repeated in Sessions 85 and 86, but the stimuli for these sessions were Set 3 (*bed, cat, pot*) and Set 4 (*bus, car, dog*), respectively. Figure 3 shows that the scores were 6 for all tasks except anagram spelling (scores 1 for Set 3 and 0 for Set 4).

Pretesting (Sessions 87–101). The tasks used during these sessions are outlined in Table 2 (not shown in Figure 3). In Sessions 87 to 95, Mike was given only trials of the anagram spelling and retrieval tasks to maintain performance with Set 1. Sessions 96 to 98 then involved three additional tabletop tasks with stimulus Sets 2, 3, and 4: matching objects to printed words, matching pictures to printed words, and matching pictures to objects. Mike was perfect except for a score of 4 in Session 96 with Set 2. In Sessions 99 to 101, the midsession tasks were changed to matching pairs of objects and pairs of printed words to one another. These performances with stimulus Sets 2, 3, and 4 were perfect.

Testing and teaching Set 2 (Sessions 102–108). Recall that teaching and testing con-

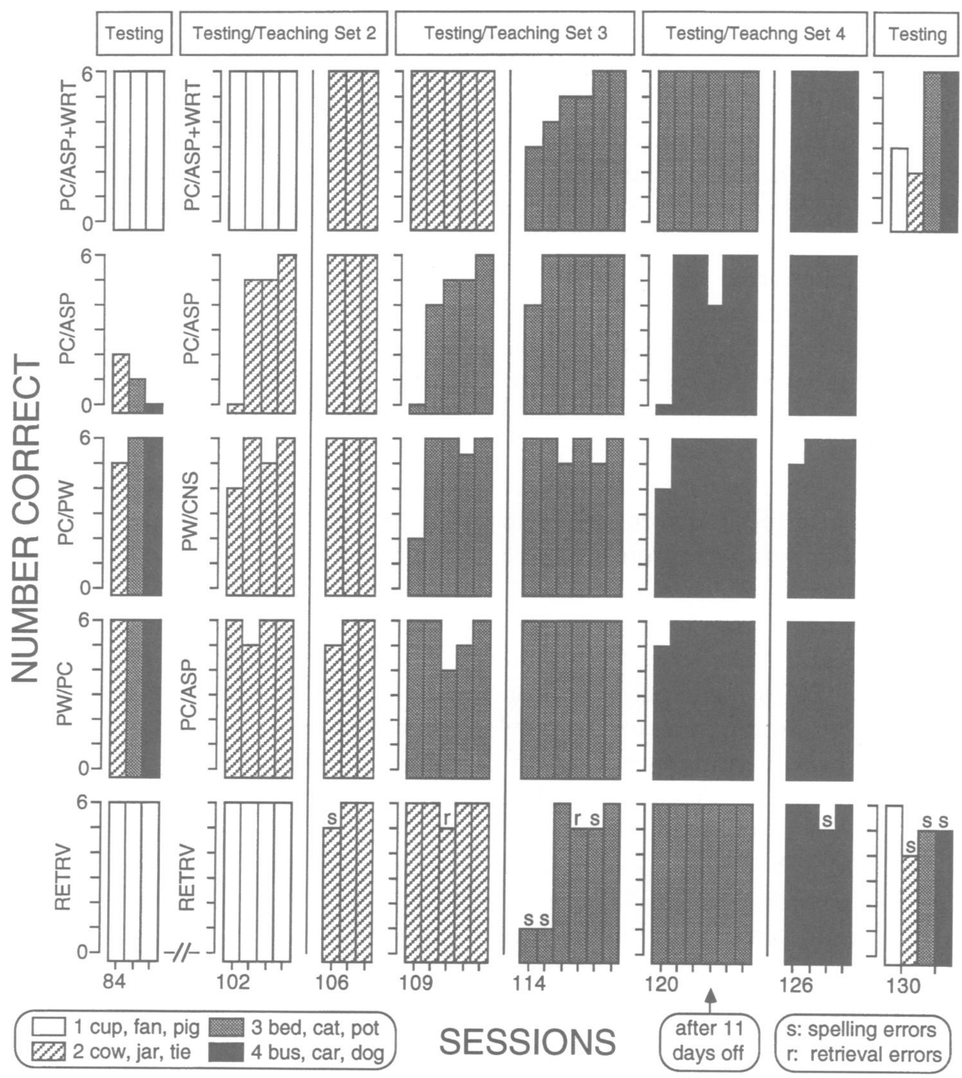


Figure 3. Mike's data for Phase 2 of Study 2: Each bar represents the number of correct trials out of six for a particular task. The tasks used are listed along the ordinates in the order in which they were given during each session. The columns of bars are arranged in groups of sessions devoted to the particular testing and teaching conditions listed on the top (Sessions 87–101 are summarized in the text). The columns of bars on the left under each testing and teaching condition reflect performances during Part 1; bars on the right reflect performances during Part 2.

ditions consisted of two parts. The goal of Part 1 was to establish anagram spelling with Set 2, while maintaining the spelling, writing, and retrieval performances with Set 1 during the first and last blocks of trials of each session. The three midsession tasks were anagram spelling (PC/ASP), delayed word construction (PW/CNS), then anagram spelling (PC/ASP) again. These sessions continued until the accuracy score for the first exposure to PC/ASP was at least 5 in three consecutive sessions. In Part 2, the stimuli in Set 2 replaced the Set 1 stimuli in the initial (PC/ASP+WRT) and final blocks of trials (RETRV) in each session. These sessions involving only Set 2 continued until scores were at least 5 on both tasks for at least three consecutive sessions.

Figure 3 shows the results for Set 2. As in pretests, Mike did not perform anagram spelling in Session 102. Mike then scored 6 when anagram spelling was repeated after the block of delayed word-construction trials. Mike met criterion in Sessions 103 to 105 with scores of 5 or better on the initial anagram spelling task. During Sessions 106 to 108, Mike was asked for the first time to write the name of each picture in Set 2 (PC/ASP+WRT), and also to write the names of two objects and then to retrieve those objects from the shelf (RETRV). Except for one spelling error, Mike was perfect during these sessions.

Testing and teaching Set 3 (Sessions 109–119). As with Set 2, Mike scored 0 on anagram spelling (PC/ASP) with Set 3 (Session 109), then quickly improved across Sessions 110 to 113. However, written spelling difficulties produced low scores in Sessions 114 and 115 when we first assessed writing to pictures (PC/ASP+WRT) and to pairs of objects during the retrieval (RETRV) task. Spelling then improved rapidly in the succeeding Sessions 116 to 119. The spelling, writing, and retrieval performances with Set 1 were well maintained in Sessions 109 to 113.

Testing and teaching Set 4 (Sessions 120–129). Initial difficulties in anagram spelling with Set 4 were followed by rapid improvement, just as with earlier stimuli. Like the results with Set 2, Mike showed near-perfect scores during first exposures to tasks involving handwriting. The performances given with Set 3 were well maintained.

Posttesting (Sessions 130 and 131). In Session 130, we reassessed performances on PC/ASP+WRT and RETRV with Set 1, then Set 2; we did the same in Session 131 but with Set 3, then Set 4. The low scores for Sets 1 and 2 reflect errors in written spelling to pictures. Most scores for the retrieval task were 5 or better; errors that occurred were always in written spelling.

Phase 3: Retrieval Procedures and Results

The purpose of Phase 3, like Phase 1 (Sessions 42–64), was to assess the role of the lists on object retrieval. The basic procedure was the same: Mike was asked to write a list of the names of two or three sample objects, then retrieve those objects from the shelf. During occasional no-list probe trials, Mike went to the shelf without the list. Compared to baseline trials with a list available, would accuracy of retrieval decrease on these probes?

In Sessions 132 to 137, the analysis began with 14-trial sessions, 12 baseline and 2 probe trials, in which the samples were pairs of familiar objects drawn from Sets 1 and 4 and the comparisons at the shelf were always all six objects. In Sessions 138 to 140, the analysis continued but with three-object rather than two-object samples. There were 12 types of three-object samples selected randomly (without replacement) from the pool of six stimuli. These same samples occurred in each of the three sessions, but their order of appearance differed.

Figure 4 shows separate scores for the writing and the retrieving parts of each trial. Scores on no-list probes represent the total number of objects correctly retrieved in a session. In Sessions 132 to 137, writing and retrieving scores on two-item baseline trials were always high, and scores on the no-list probes were all perfect for both writing and retrieving. In Sessions 138 to 140, scores on three-item baseline trials were also high. (Note that scores for these sessions represent the number of written names and objects retrieved out of six.) During the first three-item session, Mike's score on the no-list probes was 4; after that he was perfect.

In Sessions 141 to 153, the assessment of three-item performance continued; to save time, however, sessions were reduced to sev-

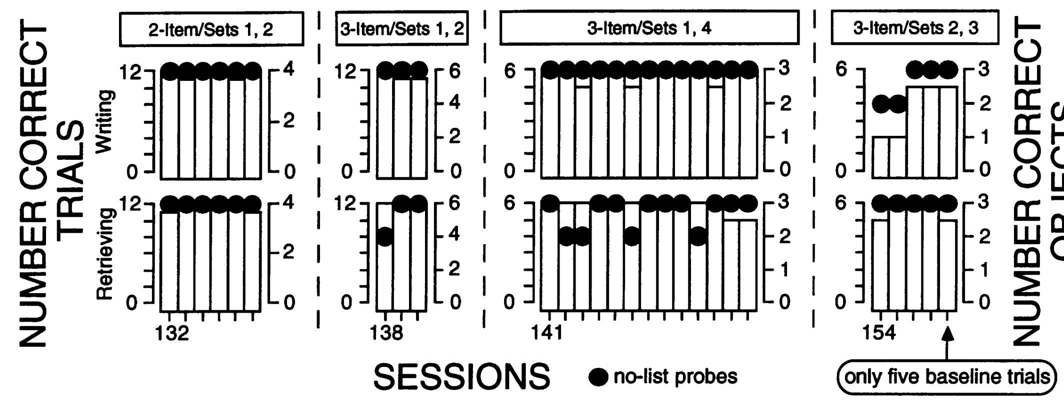


Figure 4. Mike's data for Phase 3 of Study 2: The plots for each session reflect performances for the writing and retrieval parts of each trial. Each bar represents an overall number correct on 12 or 6 baseline (list) trials; scores for these trials are reflected by the ordinates on the left of each group of data. Each filled circle represents a specific number correct on four, six, or three probe (no list) items; scores for these trials are reflected by the ordinates on the right of each group of data. The columns of bars are arranged in groups of sessions devoted to particular testing and teaching conditions.

en trials (six baseline, one probe). In addition, each three-object sample was different (quasi-randomly selected) on every trial in each session. Figure 4 shows that Mike's written spelling was nearly perfect throughout these sessions. During retrieval, most scores for baseline trials were perfect. In contrast, on several no-list probe trials Mike retrieved only two of the three objects in a sample. In Sessions 154 to 158, Mike initially made spelling errors, but retrieval scores were always high.

Signing assessment. We concluded with a brief assessment of Mike's expressive signing and finger spelling. In summary, Mike signed the names of eight (of 12) pictures, six printed words, and eight objects. Mike finger spelled 20 of 26 letters presented individually (errors on 4 needed to spell the 12 words used in this study). When shown the printed words, Mike finger spelled only 1 of the 12 words correctly. Mike did not finger spell to objects.

Discussion

Mike's results extended Claire's by showing that teaching word construction on the computer improves anagram and written spelling to pictures and also to corresponding objects during a tabletop task. That tabletop task involved writing lists of the names of two or three objects that were then used in an object retrieval task. The analysis suggested that the lists facilitated performance of both the tabletop matching (Phase 1) and object retrieval (Phase 3). For example, with the lists, Mike's scores were always high in object retrieval; without the lists, scores often declined.

We should highlight that the pictures did not immediately control Mike's handwriting in Phase 1; Mike drew the pictures instead. Mike's handwriting was apparently under strong competing stimulus control, and corrective prompts were needed to establish control by the procedure. Wide use of the present procedures will require further study to work out the details of a more complete teaching package. Mike's rapid acquisition of new spelling words suggests that the development efforts will be worthwhile.

Mike signed the names of many of the training stimuli. This repertoire may reflect the basis for Mike's performance in matching pictures, printed words, and objects to one another (cf. VanBiervliet, 1977). Mike's difficulties in finger spelling are consistent with the low spelling scores obtained on pretests in the study. Under more favorable circumstances, however, it might be possible to show emergent finger spelling. For example, positive results might have occurred had we included finger spelling in an ongoing, relevant baseline. Under such baseline conditions in the present study, Mike's anagram and written spelling performances proved to be functionally related. Further evidence of this form of intertask transfer comes from the demonstration that improvements in written spelling yield improvements in oral spelling (Stromer, 1995).

GENERAL DISCUSSION

Procedures that establish computerized spelling may yield written spelling and even wider use of that writing repertoire in other tasks. The present studies are illustrative: Computer pretesting showed that 2 individuals with developmental and hearing deficits matched pictures and printed words to one another, but neither Claire (Study 1) nor Mike (Study 2) spelled the words to pictures. A teaching package that included a delayed word-construction procedure then established these computerized anagram spelling performances. The findings replicated those of Stromer and Mackay (1992a) and extended that study because written spelling to the computer pictures also reliably emerged (see also Kinney, Stevens, & Schuster, 1988; Stromer & Mackay, 1993).

Mike's data provided other provocative examples of emergent behavior. Mike's spelling emerged in a retrieval task that entailed (a) writing a list of the names of two and three objects at a table, (b) selecting those objects from a nearby shelf, and then (c) taking the objects to the table. Mike's data may be the first to demonstrate such broad effects of computer-based teaching. The results also extended prior analyses of transfer of stimulus control (cf. Goodman & Remington, 1991) and have implications for understanding the role of mediating behavior in promoting treatment generality (Gutowski, Geren, Stromer, & Mackay, 1995; see also Kirby & Bickel, 1988; Stokes & Baer, 1977; Stromer & Mackay, in press). Overall, the present studies contribute to a growing stimulus control technology for establishing functional vocabulary skills (e.g., Browder & Lalli, 1991; Mackay, 1991; McIlvane, 1992; Remington, 1994; Singh & Singh, 1986; Stromer et al., 1992).

Both Claire and Mike matched whole printed words and pictures during pretests, thus demonstrating reading comprehension skills acquired outside the experimental setting. These data differ from Stromer and Mackay (1992a) because the matching performances did not involve spoken names. Our previous participants' receptive and expressive oral language skills thus were not necessary for the improved spelling performances observed. Moreover, aspects of Claire's data appear to replicate other studies suggesting that under some conditions spelling instruction itself may yield such matching performances (Calcagno, Dube, Galvão, & Sidman, 1994; Mackay, 1985; Mackay & Sidman, 1984; Stromer, 1995; Stromer & Mackay, 1992b, 1993). A focus on teaching spelling may be beneficial, because such instruction establishes a mode of written expression and also ensures comprehension (McNaughton & Tawney, 1993). Using the computer to accomplish such outcomes may be especially cost effective.

The present study may encourage other applications of computer-based teaching for people with disabilities. Computers are widely viewed as having substantial untapped potential for educating such individuals (Ager, 1989; Conners, Caruso, & Detterman, 1986; Schmidt, Weinstein, Niemic, & Walberg, 1985–1986). Computers permit individualized instruction that would be difficult or impossible to implement with hand-delivered procedures. However, the use of computer methods will require the development of effective approaches for promoting the generality of skills to other settings (Russo, Koegel, & Lovaas, 1978; Stokes & Baer, 1977). Devising such approaches may be a challenge when teaching individuals with disabilities who may show problems of restricted stimulus control and limited generality across tasks even in the laboratory (e.g., Lovaas, Koegel, & Schreibman, 1979; Stromer, McIlvane, Dube, & Mackay, 1993).

Our data give reason for optimism about the emergence of computer-based performances in other situations. One example is the transfer of stimulus control observed between computerized anagram spelling and handwriting. Most of the data suggested that as anagram spelling improved, so did the handwritten form. However, Mike's data illustrate the establishment of the functional relationship between anagram and written spelling via explicit teaching. Recall that special procedures were used to establish the initial instances of stimulus control of handwriting by pictures. Afterwards, the desired transfer of stimulus control reliably occurred. These outcomes may illustrate the benefits of teaching sufficient exemplars to accomplish generality of the effects of intervention (Kirby & Bickel, 1988; Stokes & Baer, 1977). However, as noted with regard to Claire, further research is needed to clarify the origins of the stimulus control involved (Stromer & Mackay, 1992a, in press).

The relationship between writing and object retrieval will also require further study. Writing the names of the sample objects may have ensured discriminative control by the stimuli, and such differential responding to the sample stimuli may have improved delayed matching accuracy (e.g., Bonta & Waters, 1981; Constantine & Sidman, 1975). However, the names written by Mike at the table actually may have exerted discriminative control of object selection at the shelf. The temporary decline in Mike's matching (Phase 1) and retrieval (Phase 3) accuracy during no-list conditions suggests that the lists may have served this additional mediating function. Stokes and Baer's (1977) notion of mediated generalization may describe the outcomes. Stokes and Baer suggested that language has unique properties as a mediator, making it easily transported from any training setting to any generalization setting. Mike's data are unique because the supplemental stimuli that facilitated performance were written rather than oral. Perhaps, as suggested by Kirby and Bickel (1988; see also Skinner, 1968), the lists provided supplemental stimuli that could serve important discriminative functions for establishing new behavioral sequences.

However, the stimulus control prerequisites for transfer across entirely different tasks are unknown. To address this issue, we and others recognize that the formation of stimulus classes may determine whether the behaviors acquired in one situation emerge in another (Albin & Horner, 1988; Kirby & Bickel, 1988). Simply defined, stimulus classes are sets of two or more stimuli that are functionally equivalent in their control of behavior (Goldiamond, 1962, 1966). Two major types of classes are involved in accounting for the data described here. In *feature stimulus classes,* the functional equivalences are based upon shared physical characteristics among the stimuli; in *arbitrary stimulus classes,* the equivalences are established by training rather than shared by physical features (McIlvane, Dube, Green, & Serna, 1993). Both feature classes and arbitrary classes may be required to enable the emergence of behavior outside its training context (Mackay, Stromer, & Serna, in press; Stromer & Mackay, in press).

As noted earlier, Mike matched printed words to pictures, pictures and objects to one another, and objects to printed words almost perfectly. These data provide evidence of feature classes, with each class including a small computer-drawn picture, a similar but larger picture on an index card, and an object. Likewise, each class of textual stimuli included words printed on the computer screen and those printed by hand on index cards. Mike's proficiency in matching these stimuli at the beginning of the study could not have occurred in the absence of these feature classes; the same is true for aspects of Claire's data. In addition, Mike's matching performances provide the basis for the inference that arbitrary stimulus classes involving the pictures, objects, and printed words had been acquired prior to this study. Mike's manual signing data support this notion and suggest that the spelling instruction described here expanded the range of performances involved.

Mike's use of the written lists to mediate object retrieval may be viewed as a by-product of the formation of the preceding feature classes and also the prior formation of arbitrary stimulus classes (Gutowski et al., 1995). The emergence of two- and three-item lists is consistent with a fundamental notion about classes: If a subset of the members of a class control a new behavior, other stimuli in the class also may exert the same control (Goldiamond, 1962, 1966). In addition, as noted earlier, prior research on class formation has shown that words produced in spelling may also function, without specific training, as printed-word samples in matching-to-sample tasks (Mackay, 1985; Mackay & Sidman, 1984; Stromer, 1995; Stromer & Mackay, 1992b, 1993). Thus, the requirements of the object retrieval task could have provided the bases for arbitrary matching in which the samples were lists of printed words and the comparisons were objects.

Mike's data are pivotal in our ongoing efforts to apply laboratory-derived methods in the teaching of individuals with serious intellectual and communication deficits. The methods used suggest a practical context for investigating stimulus class phenomena and learning processes that are involved in observation and mediation (cf. Constantine & Sidman, 1975; Mackay & Ratti, 1990). Thorough analyses of the procedures are also warranted because of their potential in such practical matters as teaching instruction following and enhancing interpersonal communication (cf. Goodman & Remington, 1991). Moreover, components of the object retrieval task resemble the production and use of shopping lists or similar written mnemonic aids (Albin & Horner, 1988) and self-control strategies (e.g., Agran & Martella, 1991; R. Baer, 1990; Ferretti, Cavalier, Murphy, & Murphy, 1993; Hughes, 1991). Further study may therefore lead to behavioral interventions capable of wide generality.

REFERENCES

Ager, A. K. S. (1989). Applications of microcomputer technology in the field of mental retardation. In J. Mulick & R. Antonak (Eds.), *Transitions in mental retardation* (Vol. 4, pp. 1–14). Norwood, NJ: Ablex.

Agran, M., & Martella, R. C. (1991). Teaching self-instructional skills to persons with mental retardation: A descriptive and experimental analysis. In M. Hersen, R. M. Eisler, & P. M. Miller (Eds.), *Progress in behavior modification* (Vol. 27, pp. 36–55). London: Sage.

Albin, R. W., & Horner, R. H. (1988). Generalization with precision. In R. H. Horner, G. Dunlap, & R. L. Koegel (Eds.), *Generalization and maintenance: Lifestyle changes in applied settings* (pp. 99–120). Baltimore: Brookes.

Baer, D. M., & Wolf, M. M. (1970). The entry into natural communities of reinforcement. In R. Ulrich, T. Stachnik, & J. Mabry (Eds.), *Control of behavior* (Vol. 2, pp. 319–324). Glenview, IL: Scott Foresman.

Baer, R. (1990). Correspondence training: Review and current issues. *Research in Developmental Disabilities, 11,* 379–393.

Bonta, J. L., & Waters, R. G. (1981). Use of manual signs in delayed matching-to-sample with developmentally disordered, speech deficient children.

Behavior Research of Severe Developmental Disabilities, 2, 51–66.

Brady, N. C., & Saunders, K. J. (1991). Considerations in the effective teaching of object-to-symbol matching. *Augmentative and Alternative Communication, 7,* 112–116.

Browder, D. M., & Lalli, J. S. (1991). Review of research on sight word instruction. *Research in Developmental Disabilities, 12,* 203–228.

Calcagno, S., Dube, W. V., Galvão, O. F., & Sidman, M. (1994). Emergence of conditional discriminations after constructed-response matching-to-sample training. *The Psychological Record, 44,* 509–520.

Conners, F. A., Caruso, D. H., & Detterman, D. K. (1986). Computer-assisted instruction for the mentally retarded. In N. R. Ellis & N. W. Bray (Eds.), *International review of research in mental retardation* (Vol. 14, pp. 105–134). New York: Academic Press.

Constantine, B., & Sidman, M. (1975). Role of naming in delayed matching-to-sample. *American Journal of Mental Deficiency, 79,* 680–689.

Dube, W. V., McDonald, S. J., McIlvane, W. J., & Mackay, H. A. (1991). Constructed-response matching to sample and spelling instruction. *Journal of Applied Behavior Analysis, 24,* 305–317.

Ferretti, R. P., Cavalier, A. R., Murphy, M. J., & Murphy, R. (1993). The self-management of skills by persons with mental retardation. *Research in Developmental Disabilities, 14,* 189–205.

Goldiamond, I. (1962). Perception. In A. J. Bachrach (Ed.), *Experimental foundations of clinical psychology* (pp. 280–340). New York: Basic Books.

Goldiamond, I. (1966). Perception, language, and conceptualization rules. In B. Kleinmuntz (Ed.), *Problem solving: Research, method, and theory* (pp. 183–224). New York: Wiley.

Goodman, J., & Remington, B. (1991). Teaching communicative signing: Labelling, requesting, and transfer of function. In B. Remington (Ed.), *The challenge of severe mental handicap: An applied behaviour analytic approach* (pp. 215–234). London: Wiley.

Gutowski, S. J., Geren, M., Stromer, R., & Mackay, H. A. (1995). Restricted stimulus control in delayed matching to complex samples: A preliminary analysis of the role of naming. *Experimental Analysis of Human Behavior Bulletin, 13,* 18–24.

Horner, R. D., & Baer, D. M. (1978). Multiple-probe technique: A variation of the multiple baseline. *Journal of Applied Behavior Analysis, 11,* 178–189.

Hughes, C. (1991). Independent performance among individuals with mental retardation: Promoting generalization through self-instruction. In M. Hersen, R. M. Eisler, & P. M. Miller (Eds.), *Progress in behavior modification* (Vol. 27, pp. 7–35). London: Sage.

Kinney, P. G., Stevens, K. B., & Schuster, J. W. (1988). The effects of CAI and time delay: A systematic program for teaching spelling. *Journal of Special Education Technology, 9,* 61–72.

Kirby, K. C., & Bickel, W. K. (1988). Toward an explicit analysis of generalization: A stimulus control interpretation. *The Behavior Analyst, 11,* 115–129.

Lovaas, O. I., Koegel, R. L., & Schreibman, L. (1979). Stimulus overselectivity in autism: A review of research. *Psychological Bulletin, 86,* 1236–1254.

Mackay, H. A. (1985). Stimulus equivalence in rudimentary reading and spelling. *Analysis and Intervention in Developmental Disabilities, 5,* 373–387.

Mackay, H. A. (1991). Stimulus equivalence: Implications for the development of adaptive behavior. In B. Remington (Ed.), *The challenge of severe mental handicap: An applied behaviour analytic approach* (pp. 235–259). London: Wiley.

Mackay, H. A., & Ratti, C. A. (1990). Position/numeral equivalences and delayed position recognition span. *American Journal on Mental Retardation, 95,* 271–282.

Mackay, H. A., & Sidman, M. (1984). Teaching new behavior via equivalence relations. In P. H. Brooks, R. Sperber, & C. MacCauley (Eds.), *Learning and cognition in the mentally retarded* (pp. 493–513). Hillsdale, NJ: Erlbaum.

Mackay, H. A., Stromer, R., & Serna, R. W. (in press). Generalization and transfer of stimulus control. In S. Soraci & W. J. McIlvane (Eds.), *Perspectives on fundamental processes in intellectual functioning.* Norwood, NJ: Ablex.

McIlvane, W. J. (1992). Stimulus control analysis and nonverbal instructional technology for people with mental handicaps. In N. R. Bray (Ed.), *International review of research in mental retardation* (Vol. 18, pp. 55–109). New York: Academic Press.

McIlvane, W. J., Dube, W. V., Green, G., & Serna, R. W. (1993). Programming conceptual and communication skill development: A methodological stimulus class analysis. In A. P. Kaiser & D. B. Gray (Eds.), *Enhancing children's communication* (Vol. 2, pp. 242–285). Baltimore: Brookes.

McNaughton, D., & Tawney, J. (1993). Comparison of two spelling instruction techniques for adults who use augmentative and alternative communication. *Augmentative and Alternative Communication, 9,* 72–82.

Remington, B. (1994). Augmentative and alternative communication and behavior analysis: A productive partnership? *Augmentative and Alternative Communication, 10,* 3–13.

Romski, M. A., Sevcik, R. A., & Joyner, S. E. (1984). Nonspeech communication systems: Implications for language intervention with mentally retarded children. *Topics in Language Disorders, 5,* 66–81.

Russo, D. C., Koegel, R. L., & Lovaas, O. I. (1978). A comparison of human and automated instruction of autistic children. *Journal of Abnormal Child Psychology, 6,* 189–201.

Schlosser, R. W., & Braun, U. (1994). Efficacy of AAC interventions: Methodologic issues in evaluating behavior change, generalization, and effects. *Augmentative and Alternative Communication, 10,* 207–223.

Schmidt, M., Weinstein, T., Niemic, R., & Walberg, H. J. (1985–1986). Computer-assisted instruction with exceptional children. *Journal of Special Education, 19,* 493–501.

Singh, N. N., & Singh, J. (1986). Reading acquisition and remediation in the mentally retarded. In N. R. Ellis & N. W. Bray (Eds.), *International review of research in mental retardation* (Vol. 14, pp. 165–199). New York: Academic Press.

Skinner, B. F. (1968). *The technology of teaching.* New York: Appleton-Century-Crofts.

Stevens, K. B., Blackhurst, A. E., & Slaton, D. B. (1991). Teaching memorized spelling with a microcomputer: Time delay and computer-assisted instruction. *Journal of Applied Behavior Analysis, 24,* 153–160.

Stokes, T. F., & Baer, D. M. (1977). An implicit technology of generalization. *Journal of Applied Behavior Analysis, 10,* 349–367.

Stromer, R. (1995). *On the benefits of direct teaching of spelling in children's language arts instruction.* Manuscript submitted for publication.

Stromer, R., & Mackay, H. A. (1992a). Delayed constructed-response identity matching improves the spelling performances of students with mental retardation. *Journal of Behavioral Education, 2,* 139–156.

Stromer, R., & Mackay, H. A. (1992b). Spelling and emergent picture-printed word relations established with delayed identity matching to complex samples. *Journal of Applied Behavior Analysis, 25,* 893–904.

Stromer, R., & Mackay, H. A. (1993). Delayed identity matching to complex samples: Teaching students with mental retardation spelling and the prerequisites for equivalence classes. *Research in Developmental Disabilities, 14,* 19–38.

Stromer, R., & Mackay, H. A. (in press). Naming and the formation of stimulus classes. In T. R. Zentall & P. M. Smeets (Eds.), *Stimulus class formation in humans and animals.* Amsterdam: North-Holland.

Stromer, R., Mackay, H. A., & Stoddard, L. T. (1992). Classroom applications of stimulus equivalence technology. *Journal of Behavioral Education, 2,* 225–256.

Stromer, R., McIlvane, W. J., Dube, W. V., & Mackay, H. A. (1993). Assessing control by elements of complex stimuli in delayed matching to sample. *Journal of the Experimental Analysis of Behavior, 59,* 83–102.

VanBiervliet, A. (1977). Establishing words and objects as functionally equivalent through manual sign training. *American Journal of Mental Deficiency, 82,* 178–186.

Vanderheiden, G. C., & Lloyd, L. L. (1986). Communication systems and their components. In S. W. Blackstone (Ed.), *Augmentative communication: An introduction* (pp. 49–161). Rockville, MD: American Speech-Language-Hearing Association.

Received April 10, 1995
Initial editorial decision July 20, 1995
Revision received October 25, 1995
Final acceptance November 9, 1995
Action Editor, Anthony Cuvo