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Effects of Multimedia Instruction on Teaching Functional Discrimination Skills to Students with Moderate/Severe Intellectual Disabilities

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ABSTRACT *The present study used a multiple probe across subjects design to evaluate the effectiveness of a multimedia computer-based instructional program in establishing match-to-sample skills, as well as to evaluate the subsequent generalisation of those skills to the natural setting. Specifically, the program used photographs depicting target stimuli (i.e., cereal boxes as they appear on grocery store shelves) in an attempt to increase the likelihood that selection of specified cereal boxes would generalise to the grocery stores in the community. In vivo probes were conducted to evaluate any generalisation of the discriminations. Results indicated that the mean and median durations to find target cereals decreased concomitant with an increase in the number of cereals found. The results are discussed in relationship to using computer-based instruction to increase the degree to which learners' skills generalise to community settings.*

Introduction

Individuals with moderate to severe intellectual disabilities have difficulty transferring learned skills across novel materials and other environmental stimuli (Langone, Clees, Oxford, Malone, & Ross, 1995). They typically learn using inefficient strategies (Beirne-Smith, Ittenbach, & Patton, 1998) and, in addition, they have difficulty responding differentially to relevant stimuli. This limits correct responding when they are presented with a task requiring multiple discriminations between items (Westling & Fox, 1995). These problems are exacerbated in community settings such as grocery stores because of the large number of distractors present (i.e., products available to consumers) (Morse, Schuster, & Sandknop, 1996). Individuals with moderate to severe intellectual disabilities may also have difficulty with mediational strategies such as grouping or restructuring the perceptual field and

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organising information needed to solve problems or complete a task (Spitz, 1979). Teaching these learners a systematic scanning technique is essential in helping them to make relevant discriminations.

Community-based instruction has been identified in the literature as an effective means for teaching students with moderate to severe disabilities the skills needed to make successful transitions to all aspects of life (Langone, 1990; McDonnell, Hardman, Hightower, Keifer-O'Donnell, & Drew, 1993; Snell & Browder, 1986). Community-based instructional programs for learners who have moderate to severe intellectual disabilities have, over the past few years, been increasingly employed (Hughes & Agran, 1993; Wolfe, 1994). Educators and community service personnel use community-based instruction to teach important skills for independent living in environments where the students are and will live, work, and engage in leisure activities.

Unfortunately, implementing high quality community-based activities is time consuming. The amount of time, or the number of community-based learning trials needed for students with moderate to severe disabilities to acquire targeted skills, may be in excess of that which some school administrators are willing to support. Logistical problems such as transportation represent additional barriers to community-based instruction. The use of technology to simulate potential learning environments is one strategy that addresses these concerns in that it may decrease the amount of community-based instructional time needed to teach functional independent living skills.

Simulated instruction involves training in non-target environments and using materials that simulate the targeted, or natural, settings (Nietupski, Hamre-Nietupski, Clancy, & Veerhusen, 1986). A number of studies are available that attempted to measure the effectiveness of simulated instruction versus in vivo training. The results of this research indicate that simulation plus in vivo training appears to improve both the effectiveness and efficiency of instruction, whereas simulation alone may not establish stimulus control so that learned skills generalise across stimulus conditions (Browder, Snell, & Wildonger, 1988; Collins, Stinson, & Land, 1993; McDonnell & Ferguson, 1988; McDonnell & Horner, 1985; McDonnell, Horner, & Williams, 1984).

In these studies simulations consisted of classroom activities that included items from community environments such as cash registers, photographs, and cardboard cutouts. Research on simulation alone versus in vivo training (McDonnell *et al.*, 1984; Neef, Lensbower, Hockersmith, DePalma, & Gray, 1990) has been limited. The results of these studies indicate that the effectiveness of simulation increases when the simulated stimuli and activities are more similar to those found in the target setting (McDonnell & Horner, 1985; Neef *et al.*, 1990). This implies that the absence of generalisation may be a function of the degree to which a given simulation does not present sufficient common stimuli. Currently available multimedia applications provide teachers with the ability to import real-life photographs and video into computer-based instructional programs, thus allowing them to provide classroom-based instruction with stimuli that are virtual representations of those found in targeted settings.

Research on the use of computer-based multimedia simulations designed to improve related functional skills has been limited (Alcantara, 1994; Haring, Kennedy, Adams, & Pitts-Conway, 1987; Wissick, Lloyd, & Kinzie, 1992). Such simulations use videodisc- or videotape-based photographs, or videos of actual events/skills being demonstrated in community environments. Haring *et al.* (1987) found videotape modeling to be effective in promoting generalisation of purchasing skills across community settings. Similarly, research on videotape modeling conducted by Alcantara (1994) also indicated generalisation of skills across settings.

There has been a paucity of research on instruction using computer-based multimedia simulations and subsequent effects on the generalisation of functional skills to community settings. One study conducted by Wissick *et al.* (1992) evaluated the effectiveness of a training program that used a computer-based interactive videodisc-based simulation of grocery shopping skills. Using this technology the authors attempted to evaluate the effectiveness of the simulation in decreasing the "extra actions" (e.g., moving up and down an aisle more than once) it took participants to locate items within the simulated store, thus improving their efficiency in shopping. The multimedia simulation was associated with a decrease in the number of extra actions it took participants to locate target items. Wissick *et al.* (1992) noted the need for research that evaluates simulation training in isolation.

The purpose of the present study was to evaluate the effectiveness of a multimedia computer-based instructional program in facilitating generalisation of match-to-sample skills to a natural setting. Specifically, the program used photographs depicting target stimuli (i.e., cereal boxes as they appear on grocery store shelves) in an attempt to increase the likelihood that selection of specified cereal boxes would generalise to grocery stores in the community. Multimedia technology provides a palette of photographs and video. In addition, computer software can be used to import text, graphics, photographs, and video. This allows teachers to produce computer-based lessons and training techniques that are more functional and realistic, and to present greater numbers of realistic learning trials. Thus, the use of multimedia technology may provide instruction that promotes generalisation via virtual stimulus and response exemplars.

Method

Participants and Settings

Three male and one female middle school students with moderate/severe intellectual disabilities participated in the study. The students' ages ranged from 13 to 15 years. Three of the students (Frank, Stan, and Sarah) were diagnosed as having moderate intellectual disabilities. Frank and Stan were also identified as having Down syndrome. The fourth student, Jeff, was nonverbal and identified as having severe autism. He engaged in hand flapping, occasional hand biting, and frequent off-task.

Students were selected for participation based on (a) teacher nomination, (b) IEP goals related to independent shopping skills, (c) an average daily attendance of 90% or better, and (d) informed consent from a parent or guardian to participate in the study. The students had also participated in a functional skills curriculum that included community-based instruction. Related and prior to the study, Sarah and Jeff received limited (i.e., less than five trials) instruction in scanning store aisles for targeted grocery items. Frank and Stan received no such instruction. In addition, each student was familiar with the computer equipment used in the study and had some exposure to commercially produced instructional software programs (e.g., computer-based language programs). Sarah, Frank, and Stan were able to independently use the mouse and to access computer programs. A system of least prompts instructional strategy and a TouchWindow (Edmark Corp.) were required for Jeff to access the computer programs.

Training was conducted in the students' classroom at a computer station located in a corner of the 30 ft × 15 ft (9.1 m × 4.55 m) classroom. The computer faced away from the rest of the class. The classroom also contained numerous tables which were used as stations for instruction in functional skills. The classroom-based pre-intervention, full, and partial probes, as well as all intervention sessions, took place on the classroom computer.

Pre- and post-intervention probes were conducted in a local grocery store (Grocery Store 1) in order to evaluate generalisation of the effects of the discrimination training. A second post-intervention probe was conducted in a second grocery store. Parts of the cereal aisle in Grocery Store 1 were photographed for use in the computer-based treatment. Thus, the order of the cereal box stimuli in the store was identical to that of the stimuli (i.e., cereal boxes) included in the computer-based presentation. In this manner, pre- and post-intervention probes in Grocery Store 1 functioned as measures of generalisation of skills related to the photographs of the cereal boxes included in the computer-based presentation. The order of the placement of the cereal boxes in Grocery Store 2, which opened for business after the conclusion of the intervention, and was therefore a novel setting for the participants, was different to that of the stimuli included in the computer-based presentation. Grocery Store 2 post-intervention probes were conducted to evaluate participants' skills with respect to a novel setting and to a different ordering of targeted stimuli. Although generalisation could not be objectively evaluated with these probes (i.e., no pre-intervention probes were conducted in this setting because it was not yet open), they were conducted to provide information related to potential generalisation.

Materials and Equipment

Seventeen photographs were taken of cereal boxes displayed on two grocery store shelves, as were 19 photographs of cereal boxes displayed on three grocery store shelves. These 36 photos were used in the development of the computer-based instructional program. In addition, 18 cereal boxes were randomly selected from the cereal boxes displayed across the 36 photos. Eighteen 4 inch × 6 inch (10.16 cm × 15.24 cm) colour photographs of these cereal boxes were then taken, one photograph per box, and subsequently used to conduct all pre- and post-intervention probes in the two grocery stores.

All photos of the cereal boxes noted above were then scanned using an Apple Color One Scanner, imported into the software program Adobe Photoshop 3.0, and adjusted for colour and size. The Photoshop JPEG files of the photos were then transferred into Hyperstudio 3.0 (Roger Wagner) where storyboards were designed so that the screens (i.e., "cards" in Hyperstudio terminology) depicting the cereal boxes varied with respect to the number of distractors (i.e., non-target cereal boxes) per screen. From all photographs taken, the final instructional program included 63 total Hyperstudio cards (i.e., screens) distributed across five tiers of difficulty. The five tiers were comprised of (a) four cards, each comprised of two cereals (one of which matched a target cereal box displayed at the top of the screen, either centered or in the left upper corner); (b) six cards, each comprised of three cereals; (c) 12 cards, each comprised of four cereals; (d) 18 cards, each comprised of two rows of 12 to 16 cereal boxes; and (e) 23 cards each comprised of three rows of 28 to 34 cereal boxes (see Figure 1). Target cereal boxes did not repeat within the a, b, c, or d tiers of difficulty. There were occasional repeats of target cereal boxes within tier e, as well as across the different tiers of difficulty. Any repeats were a function of random assignment of cereal box photos to tiers.

The final Hyperstudio instructional program was then copied onto a CD-ROM because of storage constraints of the hard drive on the computer used for the study. A Power Macintosh 7200 with CD-ROM player was used during classroom-based probes and intervention sessions. The students accessed the computer using either the mouse or a TouchWindow.

Reliability

During the computer-based intervention the instructor scored each mouse-based selection of a cereal box (or, in the case of Jeff, each TouchWindow-based selection) as a correct or incorrect match to the displayed target cereal. These scorings were in effect prompted by the screen display related to the computer program, in that correct responses resulted in the selected box moving to the displayed match and back, while incorrect selections resulted in no change in the displayed stimuli. Given that the computer program was errorless (i.e., there was 100% agreement between mouse- and TouchWindow-based student responses and the response of the computer program; as was determined over numerous observations prior to, during, and after the study), the issue of reliability was centred on whether the instructor correctly scored the computer program responses to student responses. To determine this, the classroom teacher recorded correct and incorrect student responses during one intervention session per participant. Interobserver agreement between the instructor and classroom teacher was calculated as the number of agreements divided by the sum of the number of agreements and disagreements, with the resulting quotient multiplied by 100. Interobserver agreement was 100% across all observations.

In addition, procedural reliability was determined once during each condition by the classroom teacher, who used a checklist to evaluate the integrity of the treatment procedures used by the instructor. Procedural reliability was calculated as the

FIG. 1. Photograph depicting cereal boxes in Grocery Store 1. Similar photographs were scanned into the computer-based instructional program.

number of instructor behaviours demonstrated divided by the number of instructor behaviours expected (i.e., those on the checklist), with the resulting quotient multiplied by 100. Procedural reliability was 100%.

Procedures

Dependent Measures and Independent Variables

Dependent measures included (a) percentage of cereal boxes correctly selected during pre- and post-intervention grocery store probes and during intervention sessions, and (b) duration in seconds required by participants to locate target cereals in the pre- and post-intervention grocery store probes. Correct selection was defined for grocery store probes as touching the target cereal box or retrieval of the target cereal box from the shelf (for both the verbal and picture prompt probes). For intervention sessions, correct selection was defined as either touching the target cereal box as displayed on the monitor screen (using the TouchWindow), or selecting the target cereal box with the mouse. Percent correct was calculated as the number of correct selections divided by the number of opportunities to select a target cereal box, the resulting quotient multiplied by 100. Duration data were collected only for grocery store probes. Duration was defined as the number of seconds, up to 30 s, required to select a target cereal box by either touching or retrieving it (for both the verbal and picture prompt probes). A stopwatch was used during pre- and post-intervention grocery store probes to measure duration.

The independent variables included the Hyperstudio instructional program residing on the CD-ROM and the instructional procedures within which the instructional program was imbedded.

Baseline

Table I presents the chronological sequence of the procedures, including pre-intervention probes and computer training, computer-based discrimination training using photographs of target cereal boxes, and post-intervention generalisation probes.

Grocery Store 1 probes—Pre- and post-intervention. The four participants were taken to Grocery Store 1 in order to conduct the pre-intervention probes, which included probes using (a) verbal prompts and (b) picture prompts. Probes were conducted with each participant while the remaining participants were engaged in instructional activities elsewhere in the store and under the supervision of a paraprofessional. All pre-intervention probes in Grocery Store 1 were conducted during the first session of the study. For each participant, all verbal prompt probes were conducted before the picture prompt probes. For each participant, post-intervention probes in Grocery Store 1 were conducted after each participant completed the intervention and subsequent full probe. The post-intervention probes were conducted in the same manner as were the pre-intervention probes.

TABLE I. Chronological sequence of procedures

Step 1:	Pre-intervention Probe in Grocery Store 1, Verbal Prompts (e.g., "Find the Cheerios"), 6 randomly selected cereals from list of 17 possible cereals.
Step 2:	Pre-intervention Probe in Grocery Store 1, Picture Prompts (e.g., "Find this one," teacher shows photo), 17 photos of cereals.
Step 3:	Computer training in classroom; using mouse to match-to-sample from two cereals (cereals displayed were not used in any other phase of the study).
Step 4:	Full probe (computer)—Pre-intervention, Verbal Prompts (e.g., "Find the same as the one at the top"), 63 photos of cereals.
Step 5:	Partial Probe (computer)—Pre-intervention, Verbal Prompts (e.g., "Find the same as the one at the top"), 34 photos, including four photos of two different cereals, six photos of three different cereals, 12 photos of four different cereals, six photos of two shelves of varying cereals, and six photos of three shelves of varying cereals.
	Steps 1 to 5 were conducted for all participants prior to intervention.
Step 6:	Intervention Phase—Sarah.
Step 7:	Partial Probe (computer), Verbal Prompts (e.g., "Find the same as the one at the top"), 34 photos, including four photos of two different cereals, six photos of three different cereals, 12 photos of four different cereals, six photos of two shelves of varying cereals, and six photos of three shelves of varying cereals (Step 7 was conducted for all participants).
Step 8:	Intervention Phase—Frank.
Step 9:	Partial Probe (computer), Verbal Prompts (e.g., "Find the same as the one at the top"), 34 photos, including four photos of two different cereals, six photos of three different cereals, 12 photos of four different cereals, six photos of two shelves of varying cereals, and six photos of three shelves of varying cereals (Step 9 was conducted for all participants).
Step 10:	Intervention Phase—Stan.
Step 11:	Partial Probe (computer), Verbal Prompts (e.g., "Find the same as the one at the top"), 34 photos, including four photos of two different cereals, six photos of three different cereals, 12 photos of four different cereals, six photos of two shelves of varying cereals, and six photos of three shelves of varying cereals (Step 11 was conducted for all participants).
Step 12:	Intervention Phase (I)—Jeff, match to two or three photos of cereals, criterion 70% for three consecutive days.
Step 13:	Full Probe (computer)—Sarah, Verbal Prompts (e.g., "Find the same as the one at the top"), 63 photos of cereals.
Step 14:	Generalisation Probe in Grocery Store 1—Sarah, Verbal Prompts (e.g., "Find the Cheerios"), 6 randomly selected cereals from list of 17 possible cereals.
Step 15:	Generalisation Probe in Grocery Store 1—Sarah, Picture Prompts (e.g., "Find this one," teacher shows photo), 17 photos of cereals.
Step 16:	Full Probe (computer)—Frank, Verbal Prompts (e.g., "Find the same as the one at the top"), 63 photos of cereals.
Step 17:	Generalisation Probe in Grocery Store 1—Frank, Verbal Prompts (e.g., "Find the Cheerios"), 6 randomly selected cereals from list of 17 possible cereals.
Step 18:	Generalisation Probe in Grocery Story 1—Frank, Picture Prompts (e.g., "Find this one," teacher shows photo), 17 photos of cereals.
Step 19:	Intervention Phase (II)—Jeff, match to four photos of cereals (1 row), criterion 70% for three consecutive days.
Step 20:	Full Probe (computer)—Stan, Verbal Prompts (e.g., "Find the same as the one at the top"), 63 photos of cereals.
Step 21:	Generalisation Probe in Grocery Store 1—Stan, Verbal Prompts (e.g., "Find the Cheerios"), 6 randomly selected cereals from list of 17 possible cereals.
Step 22:	Generalisation Probe in Grocery Store 1—Stan, Picture Prompts (e.g., "Find this one," teacher shows photo), 17 photos of cereals.
Step 23:	Intervention Phase (III)—Jeff, match to 10 photos of cereals (two rows), criterion 70% for three consecutive days.
Step 24:	Full Probe (computer)—Jeff, Verbal Prompts (e.g., "Find the same as the one at the top"), 63 photos of cereals.
Step 25:	Generalisation Probe in Grocery Store 1—Jeff, Verbal Prompts (e.g., "Find the Cheerios"), 6 randomly selected cereals from list of 17 possible cereals.
Step 26:	Generalisation Probe in Grocery Store 1—Jeff, Picture Prompts (e.g., "Find this one," teacher shows photo), 17 photos of cereals.
Step 27:	Post-intervention Probe in Grocery Store 2 (novel environment)—All participants, Verbal Prompts (e.g., "Find the Cheerios"), 6 randomly selected cereals from list of 17 possible cereals.
Step 28:	Post-intervention Probe in Grocery Store 2 (novel environment)—All participants, Picture Prompts (e.g., "Find this one," teacher shows photo), 17 photos of cereals.

For verbal and picture prompt probes the instructor positioned the target participant within 3 m of the target cereal, which was embedded on its shelf within numerous distractor cereals. For verbal prompt probes the instructor then presented the participant with a verbal prompt directing the student to find the target cereal (e.g., "Find the Peanut Butter Crunch"). A stopwatch was started at the conclusion of the prompt. If the student selected the target cereal within 30 s a plus was scored to indicate a correct response, and the duration of the correct selection recorded. A minus was recorded to indicate an incorrect selection or no selection having been made within 30 s. This procedure was repeated for each of six target cereals. The six cereals, which had been randomly selected from the 17 target cereal boxes, were used across participants. The same six cereals were used in the post-intervention Grocery Store 1 and Grocery Store 2 verbal prompt probes.

All 17 target cereals were used for all picture prompt probes. For picture prompt probes the instructor presented the participant with a 5 inch × 7 inch (12.7 cm × 17.78 cm) photograph of the target cereal and said "Find this one." If the student selected the target cereal within 30 s a plus was scored to indicate a correct response, and the duration of the correct selection recorded. A minus was recorded to indicate an incorrect selection or no selection having been made within 30 s.

Computer assessment—Pre-intervention. Following pre-intervention probes a short assessment session was conducted in order to determine if the participants were able to follow the match-to-sample presentation format of the computer-based instructional program. Each participant was instructed to select from two cereals displayed the one that matched the cereal displayed above the two. This allowed the participants to demonstrate their ability to use the mouse or the TouchWindow to control the computer program. This assessment revealed that Sarah, Frank, and Stan could manipulate the computer-based program using the mouse. Jeff required the TouchWindow with occasional physical (e.g., touch on elbow) and gestural (e.g., point to screen) prompts. The cereal boxes depicted during this assessment were not used at any other time during this study.

Full probes—Pre- and post-intervention. Subsequent to the verbal and picture prompt probes conducted in Grocery Store 1, a full probe (i.e., including a photo of each of the 63 target cereals) was conducted on the computer in order to establish participants' pre-intervention skill at matching each of the 63 target cereals (as displayed either in the upper left hand corner of the screen, or centered at the top) to an identical depiction of the same cereal embedded within a photo of distractor cereals. Each of these embedded depictions was displayed within varying tiers of difficulty (see Materials and Equipment section above). The computer-based full probe of all 63 target cereals was repeated with all students following the last student's intervention.

Owing to the large number of cereal box probes, each of the pre- and post-intervention full probes were conducted across two subsessions within the same day, with a 20 min break between subsessions. Each participant was told to find the target cereal (i.e., "Find the same as the one at the top"). Based on participants' performance related to duration per match-to-sample, it was determined that subsequent probes for all participants except Jeff could be conducted in one session. For each trial during full probes, the trainer instructed the participants to "Find the same as the one at the top" and then recorded (yes or no) whether they correctly matched the cereal boxes. A correct response was defined as clicking the mouse on that area of the screen that depicted the cereal box embedded within the distractor cereals. If the correct match was chosen, an animated logo from the chosen cereal box moved to the target cereal box at the top/middle of the screen, and then back to the correctly chosen box. The duration of the animation was approximately 5 s. When an incorrect cereal box was chosen, no animation resulted, as was the case for any response other than a correct match. No verbal feedback was provided for either correct or incorrect responses.

Partial probes—Pre-intervention and repeated. A partial probe was conducted with each participant prior to the initial full probe. Partial probes were also conducted with all participants prior to each participant's intervention. All partial probes, including data collection, were conducted in the same manner as the full probes, except that only 34 cards were presented during partial probes, as compared to the 63 cards used in the full probes. Partial rather than full probes were conducted at these times to decrease the likelihood that participants would become fatigued and/or frustrated due to the large number of stimuli associated with the full probes.

Each partial probe was conducted with all of the cards depicting two cereals (4 cards), three cereals (6 cards), and four cereals (12 cards). A subset of six cards from the 20 cards depicting two rows of cereals, and a subset of six cards from the 21 cards depicting three rows of cereals, were randomly selected and also used in the partial probes. A new subset was randomly selected for each partial probe. Using only 12 of these 41 cards allowed the number of stimuli associated with the partial probes to be limited. Randomly selecting these 12 cards for each partial probe (across the four participants) helped to control, albeit partially, for any differential effects in performance that could have been affected by repeated exposure to the same set of cards.

Grocery Store 2 probe—Post-intervention. Following the completion of the final student's intervention (Jeff), and his full computer-based and Grocery Store 1 post-intervention probes, post-intervention verbal and picture prompt probes were conducted with all participants in Grocery Store 2, a recently opened public grocery store. The procedures for conducting this probe were identical to those of the Grocery Store 1 pre- and post-intervention probes. Thus, all students received verbal prompt probes on the six cereals employed for Grocery Store 1, and picture prompt probes on all of the 17 target cereals. Although the procedures for the Grocery Store 2 probes were the same as those for the Grocery Store 1 probes, the cereals in Grocery Store 2 were arranged differently on the shelves.

Experimental Design

A multiple probe across subjects design (Johnson & Pennypacker, 1980) was used to evaluate the effectiveness of the computer-based instruction on the discrimination of displayed cereal boxes. In addition, in vivo probes were conducted to evaluate any generalisation of the discriminations (i.e., generalisation to Grocery Store 1).

Results

Computer-Based Intervention

Sarah, Frank, and Stan all correctly matched above 80% across all pre-intervention full and partial probes, as well as their post-intervention repeated partial probes (all at 100%), regardless of whether the target cereal was paired with one, two, or three other cereals on the computer, or imbedded within two or three rows of cereals (see Figure 2). Jeff's pre-intervention performance was variable within both full and partial probes. On the full probe he averaged 24.8% correct matches across all levels of difficulty, with a range of 0% to 58%. His average percent correct for each of his four pre-intervention partial probes was 28.4%, 18.4%, 38.4%, and 31.4%.

Sarah, Frank, and Stan each reached the computer-based instructional criterion (i.e., three consecutive sessions at or above 90% correct matches) on their third instructional session. Jeff correctly matched at above chance levels, but below criterion, during the first phase of his computer-based instruction, which was individualised so that the target cereal was displayed with one or two other cereals. His criterion was reset to three consecutive days at or above 70% correct matches, which he reached on the twelfth session of the phase (session 27). The second phase of his intervention presented displays of the target cereal with three other cereals (4 total cereals from which to match the target), and the third phase provided the opportunity to match the target cereal to the duplicate imbedded within two rows of cereals. Jeff met criterion in these latter two phases in 6 (session 33) and 8 (session 41) sessions, respectively. Although Jeff's percentage of correct responses during the computer-based intervention (ranging generally from 60% to 70% correct responses) was less than that of the other participants, it is noteworthy that his performance maintained within this range across phases (i.e., as tiers of difficulty increased from numbers of distractors and shelves). Due to time constraints, Jeff did not receive instruction on matching within three rows of cereals.

Each participant received a post-intervention full probe on the computer. Sarah, Frank, and Stan all matched with 100% accuracy across all levels of difficulty. Jeff averaged 66% accuracy in matching ranging from 100% (target cereal plus one distractor) to 30% (target cereal imbedded within three rows of distractors). Any effects of the computer-based intervention on computer-based performance cannot be determined. The pre-intervention full and partial probes for Sarah, Frank, and Stan may have represented a ceiling effect (i.e., there was little to no room for improvement on the post-intervention full probe). Jeff's improved pre- to post-intervention performance on the full probes (24.8% to 66%) may have been a function of the intervention but, due to the apparent ceiling effects of the other

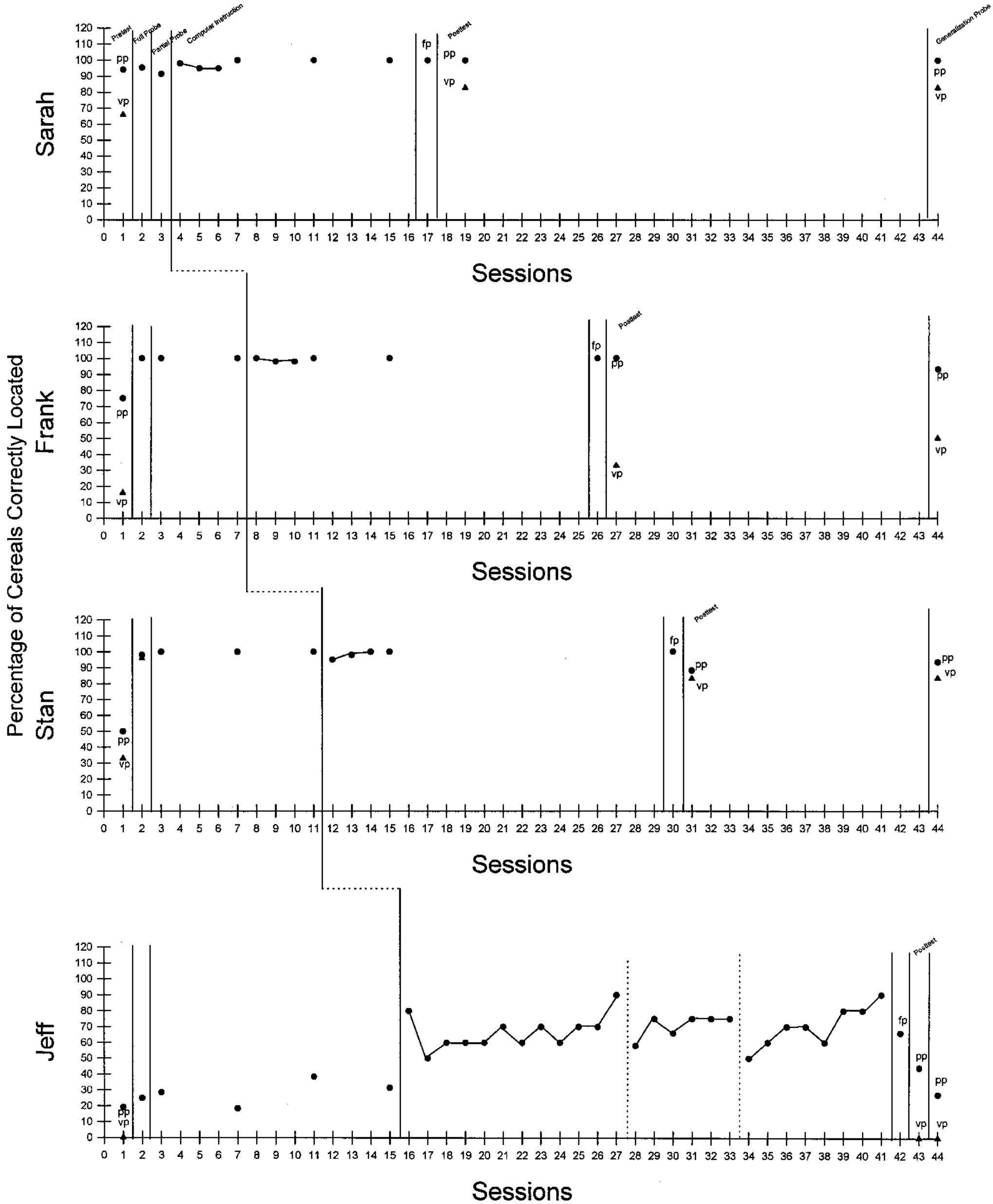

FIG. 2. Percent of cereals located correctly across students in pre-intervention and post-intervention probes in Grocery Store 1 and post-intervention probe in Grocery Store 2. PP = picture prompt, VP = verbal prompt.

participants, a functional relationship cannot be inferred because no control was established. Although the potential ceiling effect of the first three participants does not allow for conclusions regarding the effect of the computer-based instruction on the post-intervention computer-based probes, the primary focus of this study was on generalisation of computer-based discriminations to the grocery store setting.

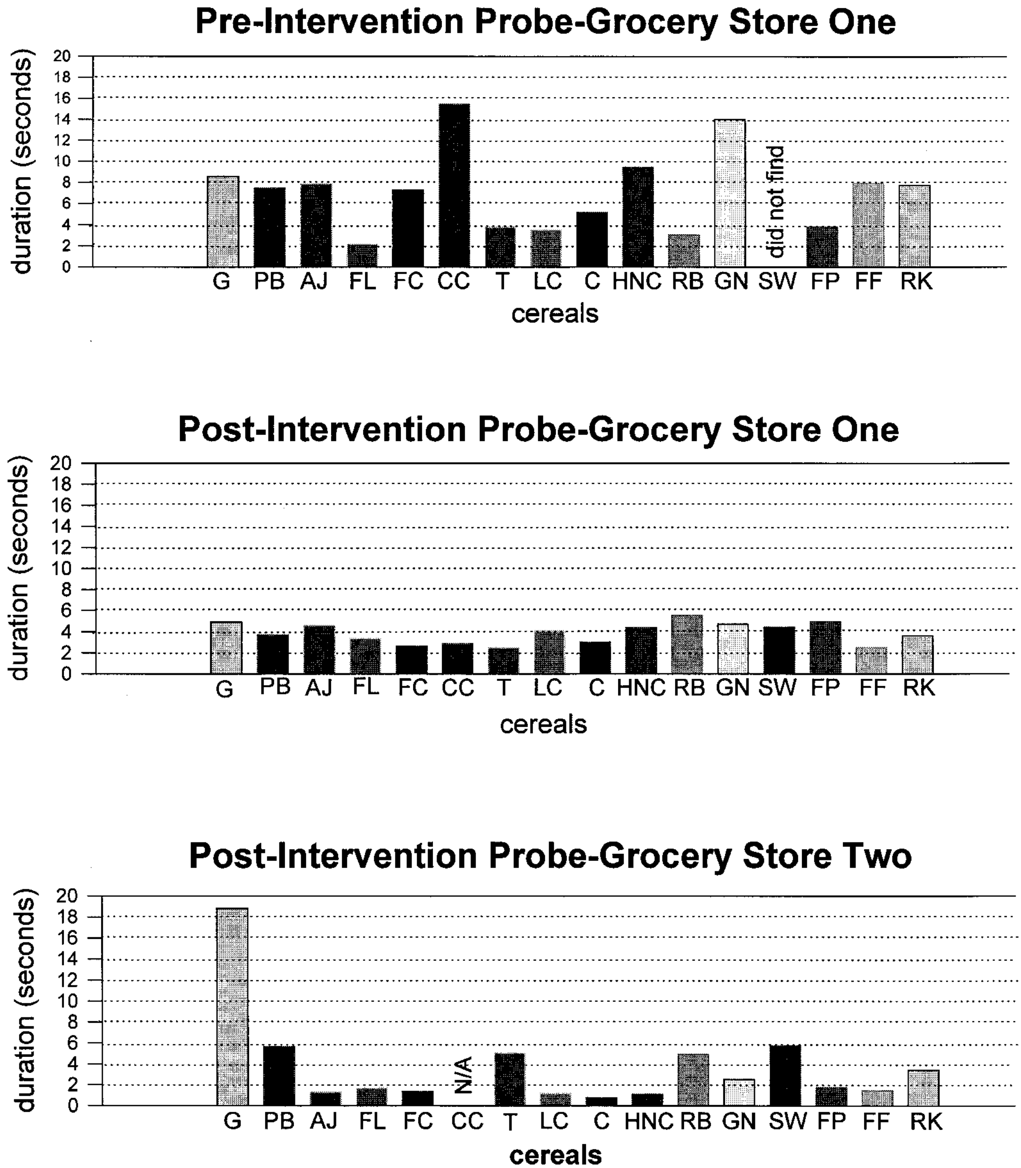

FIG. 3. Duration in seconds for Sarah to find each cereal box. Letters refer to name brand of cereals.

A functional relationship was demonstrated between the computer-based instructional program and generalisation of the dependent measures, as determined by the comparisons, described below, between pre- and post-intervention probes in Grocery Store 1 regarding the percentage of cereal boxes correctly selected (Figure 2) and the duration in seconds required by participants to locate target cereals (Figures 3–6).

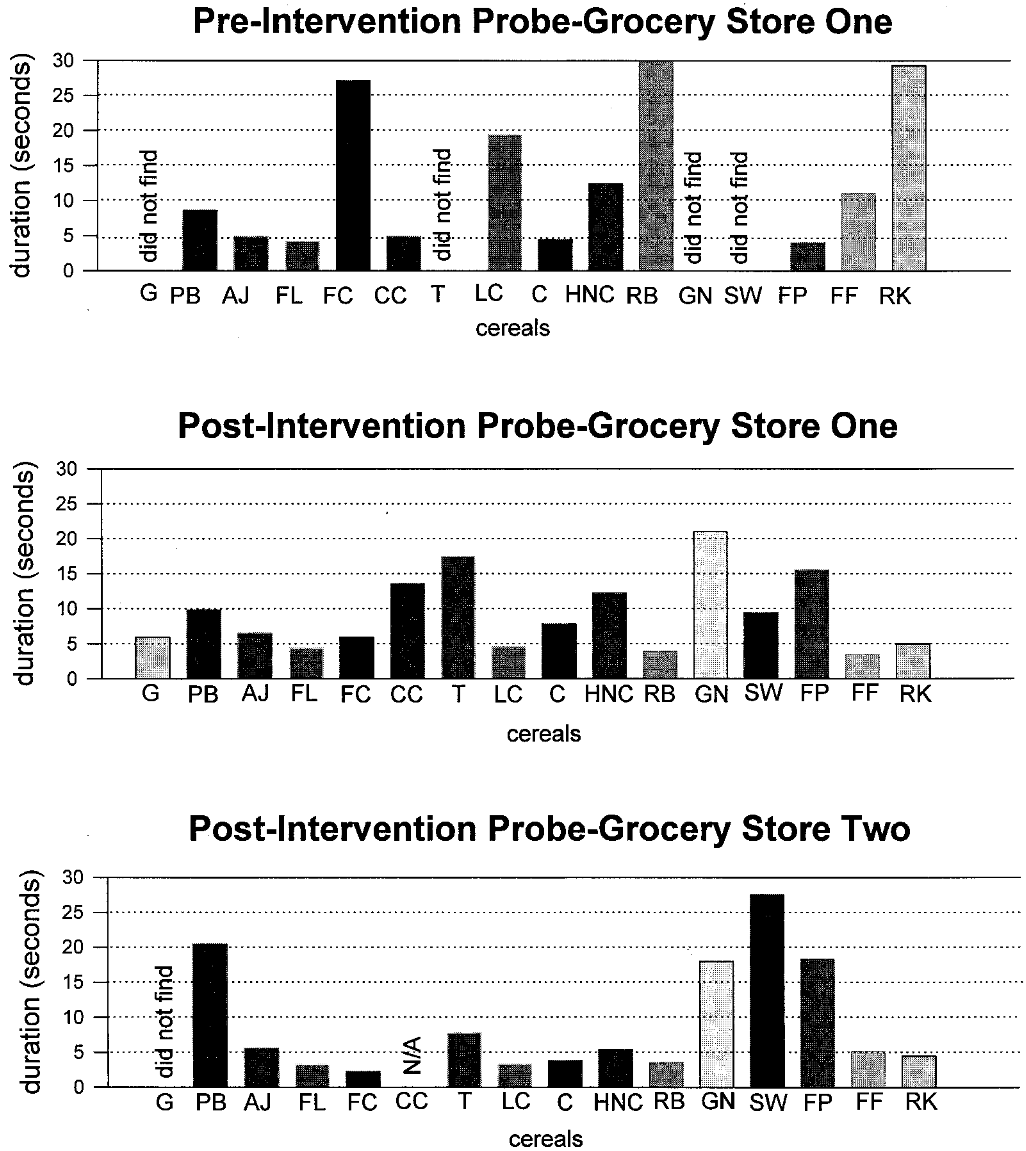

FIG. 4. Duration in seconds for Frank to find each cereal box. Letters refer to name brand of cereals.

Pre- and Post-intervention Probes—Grocery Store 1

Percentage of cereal boxes correctly selected. The first participant, Sarah, correctly matched 15 of 16 (94%) target cereals to the picture prompts (i.e., "Find this one") during the Grocery Store 1 pre-intervention probe. Her post-intervention performance under picture prompts rose to 100%. Using picture prompts, Frank, Stan, and Jeff correctly matched 75%, 50%, and 19%, respectively, of the target cereals during the pre-intervention Grocery Store 1 probe. At post-intervention, they correctly matched 100%, 88%, and 44%, respectively. Each of these post-intervention scores

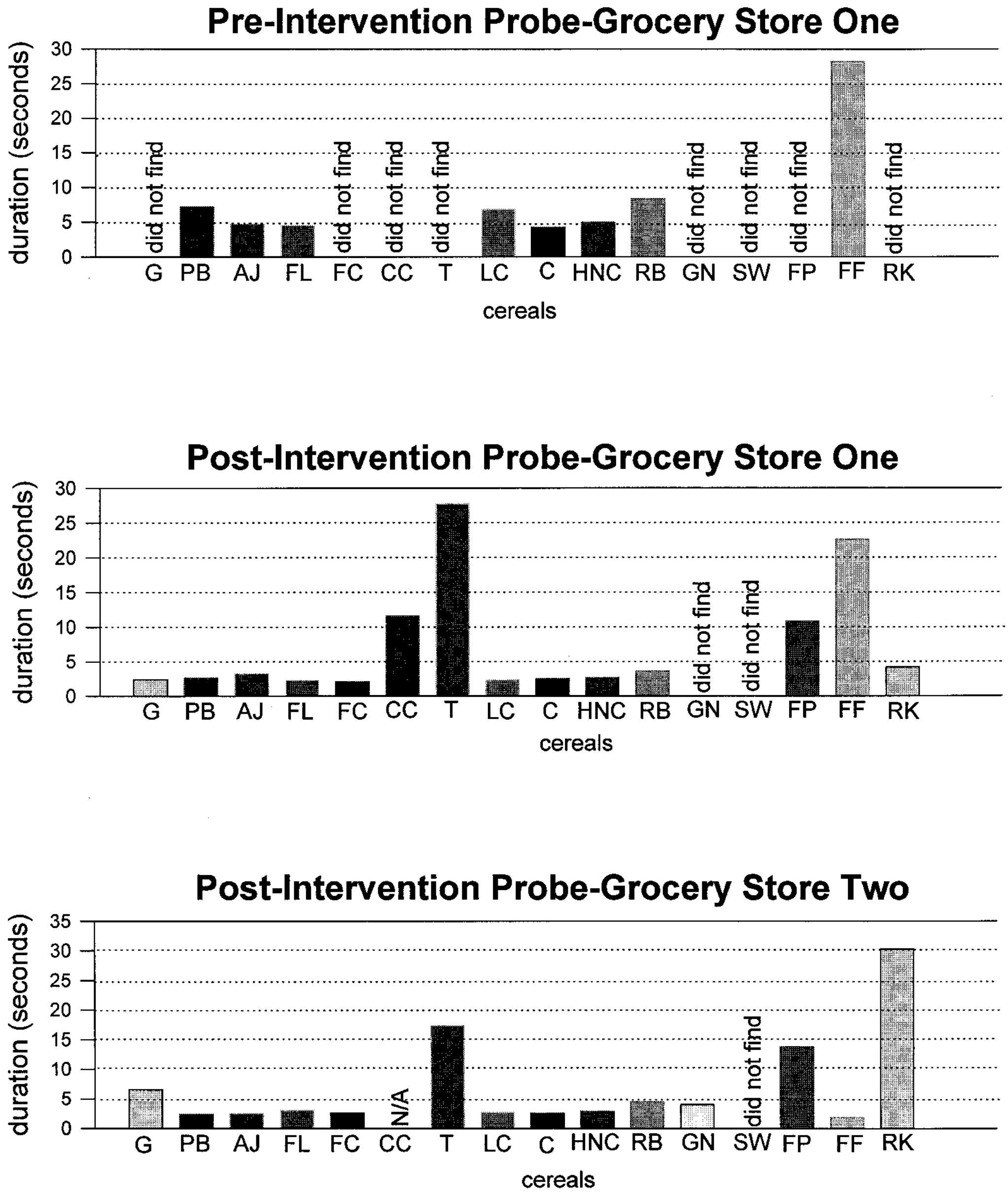

FIG. 5. Duration in seconds for Stan to find each cereal box. Letters refer to name brand of cereals.

represent an increase from those of pre-intervention. Thus, despite the ceiling effect associated with Sarah's data, a functional relationship was established across Frank's and Stan's data, with the former representing an affirmation of the effects of the computer-based intervention (i.e., the matching skills established during intervention generalised to Grocery Store 1), and the latter a replication. Jeff's data represents a second replication of generalisation to the grocery store.

Sarah correctly selected four of six (67%) cereals when given verbal prompts

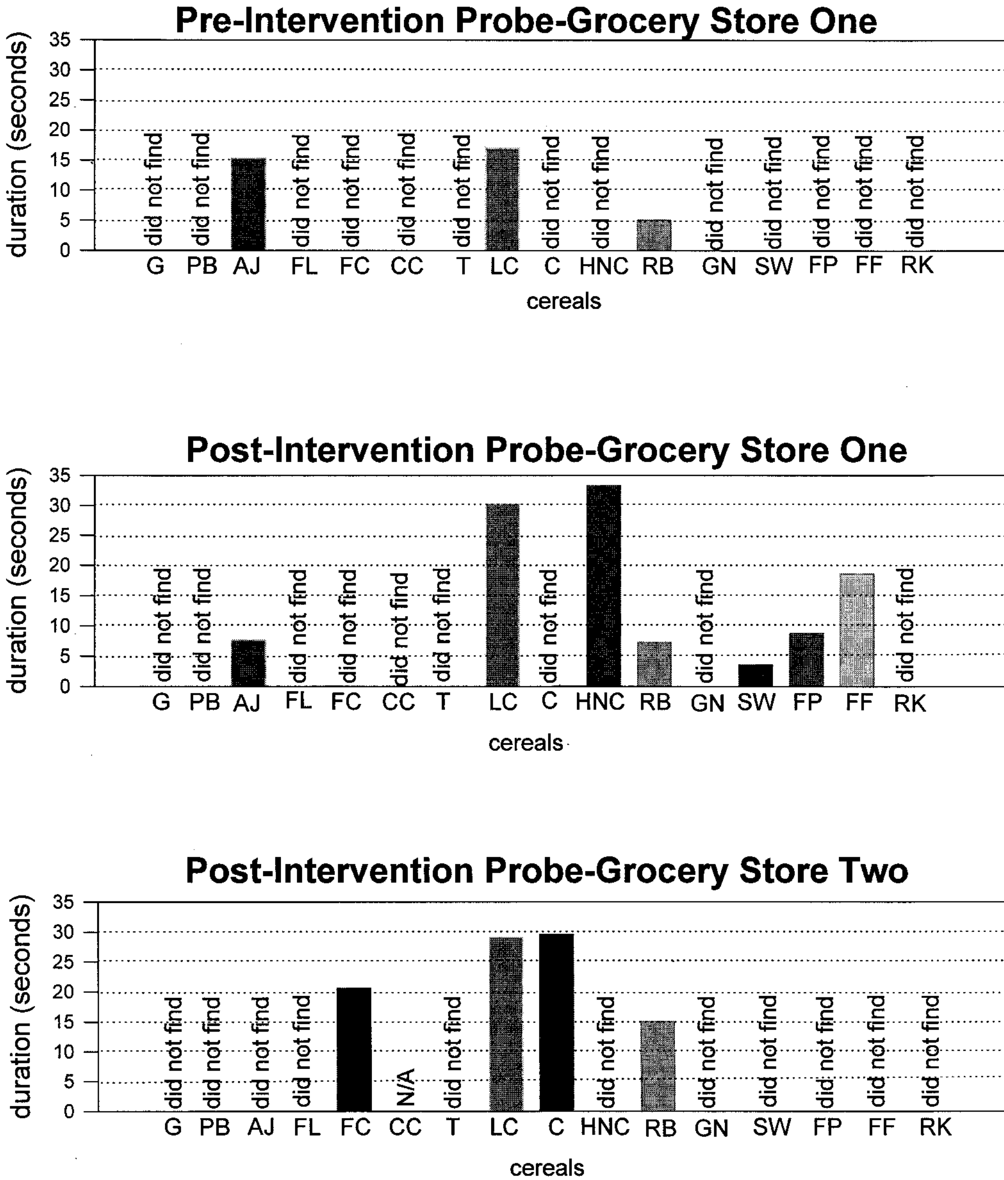

FIG. 6. Duration in seconds for Jeff to find each cereal box. Letters refer to name brand of cereals.

(e.g., "Find the total") during the pre-intervention probe. During the post-intervention probe she correctly selected five of six (83%). Frank, Stan and Jeff correctly matched 16%, 33%, and 0% during the pre-intervention verbal prompts probe and 33%, 83%, and 0% during the post-test probe. Sarah's and Frank's pre- to post-intervention verbal probes data each represent an increase in one additional correct match (of the six verbal prompts given). Stan improved from 2/6 at the pre-intervention probe to 5/6 cereals being correctly selected at post-intervention.

Jeff did not correctly select any of the cereals at each probe (0/6). Thus, from pre- to post-intervention, Sarah's performance under verbal prompts had little room for improvement, Frank's performance improved little, Stan's improved by over 100%, and Jeff's showed no improvement. Given this variability and the relatively small number of verbal prompts given, little can be concluded regarding generalisation of performance under verbal prompts.

Duration to locate target cereals.

Duration data were taken for the picture prompts across all participants (but not for the verbal prompts). Figures 2 to 5 show each subject's duration for finding each target cereal across the Grocery Store 1 pre- and post-intervention probes (a measure of generalisation of the effects of the computer-based instruction), as well as duration data for the Grocery Store 2 post-intervention probe. Figure 6 shows, per subject, the mean and median durations for each of the Grocery Store 1 and 2 probes. Sarah's duration (i.e., time taken to locate each of the target cereals) for the pre-intervention Grocery Store 1 probe averaged 8.6 s per cereal, with a median of 7.4 s. At post-intervention her mean and median durations decreased to 3.9 and 3.9 s. Sarah's mean and median post-intervention Grocery Store 2 durations (same cereals as Grocery Store 1) were 3.8 and 1.7 s. These data represent a 54.7% (mean) and 47.3% (median) decrease in the time it took Sarah to locate the target cereals on the shelves in Grocery Store 1.

Frank's mean and median durations also evidenced a marked decrease from pre- to post-intervention probes in Grocery Store 1; his mean decreased from 17.5 to 9.1 s, his median decreased from 15.9 to 7.2 s. His Grocery Store 2 mean and median were 10.6 and 5.3 s. These data represent a 48% (mean) and 54.7% (median) decrease in the time it took Frank to locate the target cereals on the shelves in Grocery Store 1.

Stan's mean and median durations decreased from the pre- to post-intervention probes in Grocery Store 1. His mean and median at pre-intervention were 19.3 and 29.5 s. At post-intervention they were 10 and 2.9 s, respectively. These data represent a 48.2% (mean) and 90.2% (median) decrease in the time it took Stan to locate the target cereals on the shelves in Grocery Store 1. In Grocery Store 2, Stan's mean and median durations were 8.4 and 2.7 s. Thus, Sarah, Frank, and Stan were able to locate target cereals during the post-intervention probe in about half the time it took to locate the cereals during the pre-intervention probe.

Jeff's pre-intervention Grocery Store 1 mean was 26.7 with a median of 30 s. His post-intervention mean decreased slightly to 23.5 s. His median remained at 30 s. These data represent a 19.8% (mean) and 0% (median) decrease in the time it took Jeff to locate the target cereals on the shelves in Grocery Store 1. Although these data reflect less improvement than that of the other participants, it is noteworthy that Jeff found seven of the 16 cereals at the post-intervention probe and only three during the pre-intervention probe. Jeff's Grocery Store 2 mean and median durations were 28.3 and 30 s. He found four cereals during this probe.

Discussion

The purpose of this study was to evaluate the effectiveness of a multimedia computer-based instructional program to effect the generalisation of match-to-sample skills to a natural setting. The computer-based program included photographs depicting target stimuli (i.e., cereal boxes as they appear on grocery store shelves) in an attempt to increase the likelihood that selection of specified cereal boxes would generalise to the grocery stores in the community.

Visual comparisons of the pre- to post-intervention percent of correct discriminations (given picture prompts and the instruction "Find this one") in Grocery Store 1 indicate that all four students correctly identified more target cereals at the post-intervention probe, although the improvement of one participant (Sarah) was marginal, perhaps due to a ceiling effect. Thus, there is strong evidence that discriminations established in the computer-based instructional setting generalised to the community-based grocery store.

The pre- to post-intervention Grocery Store 1 duration data provides the strongest evidence of generalisation. The time required for Sarah, Frank, Stan, and Jeff to locate the target cereals improved (decreased) from the pre- to post-intervention by a mean 54.7%, 48%, 48.2%, and 19.8%, respectively. Thus, all participants demonstrated a clear improvement in finding the cereals in shorter periods of time. When the participants were taken to Grocery Store 2, they found a similar number of the target cereals in a similar time frame (plus or minus a few seconds).

The pre-intervention data were such that it was not possible to determine, for three of the four participants, whether the computer-based instruction affected computer-based performance. This is due to the fact that there may have been a ceiling effect (i.e., the pre-intervention full and partial probe data for all but Jeff indicated that there was little room for improvement). In other words, all students but Jeff were able to correctly discriminate (i.e., match) the target cereals prior to the computer-based instruction. The computer-based instructional program was apparently effective in establishing correct computer-based discriminations by Jeff, albeit there was no experimental control established. Jeff's performance during the computer-based instruction was improved over that of his pre-intervention computer-based performance. This increase in percentage of correct discriminations maintained across his three computer-based instructional phases (i.e., across increasing numbers of distractors and shelves). The levels of severity of the participants may have been a factor relating to the amount of improvement available per individual. Sarah, Frank, and Stan, all of whom had moderate disabilities, demonstrated significantly greater skill levels in language, social, and independent living skills than did Jeff, who had severe disabilities. This is consistent with the premise that Sarah, Frank, and Stan were able to make relatively more complex discriminations, which may explain the discrepancy between Jeff's and the other participants, pre-intervention computer-based performance. It is possible that future research that applies computer-based simulations for teaching skills to learners who have more severe disabilities, may continue to find greater effects on skill acquisition.

The results of this study support the extant literature on the effectiveness of multimedia instruction for teaching functional skills (Alcantara, 1994; Haring *et al.*, 1987; Haring, Breen, Weiner, Kennedy, & Bednersh, 1995; McDonnell *et al.*, 1984; Wissick *et al.*, 1992). Specifically, the study addressed an important issue highlighted by Morse *et al.* (1996) who stated that "... a focus of future research should be on finding ways to ensure that skills which are learned in school-based training sites readily transfer to grocery stores in the community" (p. 512). Much of the literature suggests that simulation training is most effective when paired with in vivo training (McDonnell & Horner, 1985; McDonnell *et al.*, 1984). However, the results of this study indicate that computer-based simulations alone may produce generalisation and therefore be at least as effective as in vivo training in establishing skills in community-based settings, and potentially more cost effective. This places "the onus on teachers ... to provide environmental arrangements that establish discriminative stimuli associated with normative behaviors and reinforcers ..." (Clees, 1995, p. 125). The results of the current investigation also suggest that this may apply across levels of severity.

Of particular importance is the data that indicates the effects the computer-based simulation appeared to have on the participants' ability to efficiently locate cereal boxes among distractors. Individuals with cognitive deficits are inefficient learners (Beirne-Smith *et al.*, 1998) who have difficulty following patterns or using systematic visual scanning procedures (i.e., left to right, top to bottom). The students in the study were encouraged to scan the rows during the computer-based intervention when the screen presented a photograph of grocery store shelves with target cereals imbedded among distractors. These stimuli allowed participants a more accurate depiction of the actual shelves they would see in the store.

The use of this type of multimedia instruction appears to assist learners in gaining more efficient location strategies. For example, during the pretest Frank and Stan would travel up and down the cereal aisle when they did not immediately locate the targeted cereal. Improvement in duration measures support informal observations that they were able to focus within specific areas to locate cereals when they returned to Grocery Store 1 and during their trip to the novel store.

Finally, this study presents the use of a technology that has decided advantages over previously used technological solutions for teaching community valid skills. Past studies used videotape and videodisc technologies to present instructional scenarios and demonstrated that these scenarios did positively effect learned behaviours and potentially assist learners in generalising these skills once learned (e.g., Haring *et al.*, 1987; Wissick *et al.*, 1992). Unfortunately, videotape technology is linear in nature and requires considerable difficulty in locating and repeating important sequences on the tape that students may need to view for additional practice. Videodisc technology overcomes this weakness, but requires considerable expense to create each videodisc and the medium is limited by a relatively short number of video sequences that can be stored on one disc (i.e., 30 min of full motion video).

The current investigation employed photographs stored on a CD-ROM instead of video. However, compressed video could also have been used for instruction, thus allowing for considerably more flexibility than previous technological solutions. This technology provides easy access to full motion or compressed video to (a) support instructional procedures designed to teach concepts, (b) highlight (increase the salience of) relevant dimensions of stimuli, and (c) allow for virtually unlimited practice. Future research efforts should address the effectiveness of current and emerging technologies (e.g., compressed video and DVD) on improving generalisation of skills to in vivo settings more efficiently.

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