Investigating the Acquisition, Generalization, and Emergence of Untrained Verbal Operants for Mands Acquired Using the Picture Exchange Communication System in Adults With Severe Developmental Disabilities

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This study compared the total amount of training time and total number of trial blocks for individuals with severe developmental disabilities to acquire mands under control of unconditioned establishing operations and mands under control of transitive conditioned establishing operations for manual sign and for the Picture Exchange Communication System (PECS). Also examined was the generalization of mands across settings and communicative partners, as well as the emergence of untrained tacts and intraverbals for mands acquired using PECS. Mands for preferred items and for items needed to complete a chained task were acquired more rapidly and in fewer training blocks for PECS than for manual sign. Moreover, mands established using PECS generalized across settings and communicative partners. Finally, untrained tacts and intraverbals using PECS were shown to emerge for some of the participants following PECS training. These results suggest that PECS may be a viable alternative communication system for adults with severe developmental disabilities who have little or no history of systematic instruction and limited imitative repertoires.

Key words: manding, PECS, verbal behavior, motivating operations

Adults with severe developmental disabilities often lack functional communication skills and are thus candidates for alternative communication systems. A number of issues warrant consideration when habilitation staff are faced with the decision of which system to select, including the individuals' fine motor skills and the amount of effort required by staff to maintain the system. Other important issues include the degree to which the individual's communication skills will be demonstrated in a variety of circumstances, as well as the degree to which verbal skills taught using a particular system are pivotal for the emergence of other verbal skills. Manual sign, which involves approximations of hand gestures used in American Sign Language, has been used frequently with individuals with developmental disabilities with considerable success. For example, Carr and Kologinsky (1983) found that children with autism acquired a requesting repertoire using manual sign following incidental teaching. Generalization of spontaneous requests was observed across communicative partners and set-

tings, and self-stimulatory behaviors were shown to decrease (see also Miller, Collins, & Hemmeter, 2002).

A number of advantages of using manual sign have been noted, including the fact that materials external to the body, such as a communication book or voice output system, are not required, such that the system is always accessible (Mirenda, 2003). In addition, when communicating via manual sign, the message can be delivered quickly, as would not be the case with a communication board or book which involves flipping through pages or scanning an array of pictures (Miller, 1993, p. 331). Manual sign is not without disadvantages, however, including the fact that a number of potential communicative partners may not be proficient in manual sign, thus restricting the size of the individual's verbal community (Schwartz, Garfinkle, & Bauer, 1998). Manual sign may also be particularly challenging for individuals with limited fine motor skills, a common characteristic of individuals with severe developmental disabilities.

A second alternative communication system that has grown in popularity for children with autism, despite limited research on its efficacy, is the picture exchange communication system (PECS) (Bondy & Frost, 1994). PECS teaches individuals to communicate by handing a pic-

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ture of a desired item to a caregiver, in exchange for the preferred item itself. Often the pictures are contained in a three-ring binder that the individual keeps on his or her person. More advanced learners may be taught to construct sentence strips, in which "I want," "I see," and "I have" sentences are exchanged with another person. The logic underlying the exchange of pictures and/or sentence strips is that the exchange parallels the social exchange that takes place over the course of regular conversation. A number of case studies have shown PECS to be successful in establishing rudimentary communication skills in children with autism and related disorders (e.g., Bondy & Frost, 1993; Bondy & Battaglini, 1992; Schwartz, Garfinkle, & Bauer, 1998). In one of the only methodologically rigorous investigations of PECS, Charlop-Christy, Carpenter, Le, LeBlanc, and Kellet (2002) examined the time for three children with autism to acquire communication skills using PECS, and also the effects of PECS instruction on the emergence of speech and frequency of challenging behaviors. Results showed that the children met criterion for each training phase in an average of 170 minutes and 246 trials, and spontaneous speech was shown to increase and challenging behaviors were shown to decrease.

PECS affords several potential advantages, including the fact that complex motor movements are not required, and it is easily understood by others (Charlop-Christy et al., 2002). Possible disadvantages have been noted as well, including the necessity of a communication book which holds the individual's pictures, which may be laborious to carry at all times and time consuming for staff to maintain (Mirenda, 2003). Sundberg (1993) suggested that the depiction of complex words in pictorial form, such as prepositions, may be particularly complicated using PECS.

Skinner's (1957) analysis of verbal behavior has provided a popular framework in which language training curricula for persons with severe developmental disabilities are currently delivered. Selecting the appropriate communication form for an individual might be aided with a consideration of how verbal operants, defined by Skinner (1957), might be most readily established. The mand, or "a verbal operant in which the response is reinforced by a characteristic consequence and is therefore under the functional control of relevant conditions of

deprivation or aversive stimulation" (pp. 35–36), is often made the target of early language training efforts. When teaching mands, careful attention must be paid to motivational variables or establishing operations (EOs). Michael (1988, 1993) defined the EO as "an environmental event, operation, or stimulus condition that affects an organism by momentarily altering (a) the reinforcing effectiveness of other events and (b) the frequency of occurrence of that part of the organism's repertoire relevant to those events as consequences" (p. 192). Michael (1993) differentiated between two types of establishing operations, unconditioned (UEOs) or unlearned EOs and conditioned (CEOs) or learned EOs. Signing for a desired beverage when thirsty would be an example of a mand under UEO control. Michael further identified several types of CEOs, one being the transitive CEO. A transitive CEO involves a stimulus in which the effectiveness of a conditioned reinforcer is dependent upon another stimulus. Exchanging a picture of an inaccessible item needed to complete a daily living task would be an example of a mand under transitive CEO control. Using a technique called the interrupted chain procedure, Hall and Sundberg (1987) taught adolescents with severe mental retardation to mand for items, such as a quarter needed to complete the task of making a vending machine purchase, by signing for the needed item. Once the chained task was established in the participants' repertoires, contriving the transitive CEO proved to be an effective technique for establishing the particular mand. The mand is to be distinguished from the tact, which is also often granted early emphasis in language training efforts, defined by Skinner (1957) as "a verbal operant in which a response of given form is evoked by a particular object or event or property of an object or event" (pp. 81–82), and the intraverbal, "a verbal operant in which the form of the response is controlled by verbal stimuli that lacks point-to-point correspondence with the response" (Skinner, 1957, p. 71). Requesting is often viewed as a form of manding, while naming, labeling, and describing are frequently used synonymously with tacting (Sigafos, Doss, & Reichle, 1989). Answering simple questions or engaging in more complex conversation can be considered examples of intraverbal responding.

Potential advantages and disadvantages of PECS and manual sign that are inspired by

Skinner's (1957) analysis of verbal behavior have been expressed, but not all of which have been put to rigorous experimental testing. Manual sign has been called topography-based verbal behavior because the form of each response differentiates one response from another, much like vocal speech (Sundberg, 1993). PECS, on the other hand, consists of first scanning an array of pictures and then exchanging the picture, and can be called selection-based verbal behavior for this reason. This differs from vocal speech and manual sign in that two responses for a single communicative episode are required, and the response topography is the same for every response (Sigafoos, 1998). While Sundberg (1993) maintains that the parallel between manual sign and vocal speech may make sign a more preferable communication modality, Sigafoos (1998) suggests that because the speaker need only learn one response topography using PECS, it may be acquired more rapidly than manual sign, which requires the recall of numerous topographies (see Chambers & Rehfeldt, 2003). Another potential concern with PECS is that the system teaches impure, or multiply controlled, verbal operants. This is due to the fact that throughout the early phases of training, each preferred item is present on a given trial. Thus, an individual learns to exchange a picture not only when deprived of a given item, but when in the presence of a preferred item itself. Because the response is controlled by both a nonverbal antecedent stimulus and an EO, Bondy, Tincani, and Frost (2004) refer to such a response as a multiply controlled mand, or a mand-tact. Similarly, later phases of PECS training teach the individual to respond to questions such as "What do you see?" and "What do you have?" while in the presence of a particular stimulus. Responses are thus brought under control of nonverbal antecedent stimuli and verbal antecedent stimuli, leading Bondy et al. (2004) to define such responses as tact-intraverbals. That PECS establishes multiply controlled verbal operants need not necessarily be regarded as a drawback of the system, however. It is possible that PECS training may lead to the emergence of untrained tacts and intraverbals because multiply controlled mands are established during training. A number of studies have suggested that the verbal operants are functionally independent (e.g., Sigafoos, Doss, & Reichle, 1989), but if PECS

facilitates the emergence of verbal skills in a repertoire that has not been directly trained, this may reflect an advantage of PECS relative to other communication systems. Moreover, one would be hard-pressed to identify strategies other than PECS for establishing an initial mand repertoire that does not involve antecedent control over manding.

The purpose of the present study was to compare the acquisition and generalization across settings and communicative partners of mands for preferred items (under UEO control) and mands for items needed to complete a chained task (under transitive CEO control) for manual sign versus PECS. Also compared was the degree to which untrained tacts and intraverbals, in each communication modality, would emerge following training in each modality. Importantly, this study was conducted with adults with severe developmental disabilities, each of whom had histories of limited systematic instruction in any area. This is a population that has been included very infrequently in studies on either PECS or manual sign (see Chambers & Rehfeldt, 2003).

METHOD

Participants

Louie was a 51-year-old male diagnosed with severe mental retardation, intermittent explosive disorder, and blindness in his left eye. Louie had an IQ score of 24 and a mental age of 2 years and 8 months according to the Stanford-Binet Intelligence Scale, Form L-M. According to the Inventory for Client and Agency Planning (ICAP), Louie's adaptive behavior age equivalent was 3 years and 11 months and his social and communicative age equivalent was 1 year and 8 months. Louie took 10 mg of Zyprexa[®] once daily to help manage aggression throughout the duration of the study. Louie had been institutionalized for the majority of his life and had no history of direct or tabletop instruction of any kind. Louie was nonvocal and primarily communicated using gestures. Louie imitated a small number of one-step gross motor movements.

Bonnie was a 42-year-old female diagnosed with profound mental retardation, intermittent explosive disorder, seizure disorder and obesity. According to the Stanford-Binet Intelligence Scale Form L-M, Bonnie had an IQ score

Table 1
Preferred Items Used During PECS and Manual Sign Training for Each Participant

Participant	PECS	Manual sign
Louie	Lemonade Applesauce Cookie Magazine Baseball cards	Diet Coke® M&M's® Book Paper & pencil Radio
Bonnie	Cupcake Paper & pencil Applesauce Lemonade Magazine	M&M's Radio Cookies Diet Coke Book
Robin	Magazine Deck of cards Connect Four® Puzzle Beads	Book Memory game Paper & pencil Ball Radio

of less than 20 and a mental age of 24 months. Bonnie scored an age equivalent of 2 years and 5 months on the ICAP. In the social and communication domain, her age equivalent was 1 year and 10 months. Throughout the duration of the study Bonnie took 100 mg of Luvox® once daily for help managing aggression. Bonnie had been institutionalized for the majority of her life and had no history of tabletop or direct instruction of any kind. Bonnie was nonvocal and primarily communicated using gestures. Bonnie did not imitate any one-step gross motor movements.

Robin was 52-year-old female diagnosed with mild mental retardation, mood swings and depression. Despite her diagnosis of mild mental retardation, Robin's overall adaptive behavior age equivalent according to the ICAP was 3 years and 1 month. Her lowest score on the ICAP was in social and communicative functioning, in which she scored an age equivalent of 1 year and 10 months. For the duration of the study Robin took 1 mg of Haldol® daily and 20 mg of Celexa® daily for help managing aggression and depression. Robin had lived with family members for the majority of her life and had never attended school. Thus, she had received minimal instruction in any skill area. Robin vocalized approximately 4 unintelligible words and used pointing and gestures to com-

municate. Robin imitated a small number of one-step gross motor movements.

Setting and Stimulus Materials

Mands for preferred items were taught in one of two secluded classrooms at the participants' developmental training program center. The classrooms contained a teacher's desk, tables, and chairs. Instructional materials included a 1-in. three-ring binder for each participant. Each page of the binder, including the cover, consisted of three Velcro strips placed horizontally upon the binder. The binders contained 2 in. x 2 in. laminated photographs of preferred and distracter items. Preferred items for each participant consisted of edible and tangible items, as shown in Table 1.

Mands under transitive CEO control were taught in the kitchen at the facility, which included a table, several chairs, a refrigerator, stove, oven, sink, and several small appliances. Instructional materials included the same binders that were used in teaching mands for preferred items, but the pictures included in the binder consisted of 2 in. x 2 in. laminated photographs of various items needed to complete the chained tasks of preparing pudding and preparing iced tea. Other materials used to teach mands under transitive CEO control are shown in Table 2.

Table 2
Materials Needed for the Interrupted Chain Procedure Tasks

Task	Response modality	Materials needed
Making pudding	PECS	Pudding mix, milk*, whisk* measuring cup, mixing bowl*, timer
Making iced tea	Manual sign	Iced tea mix, cup*, water, pitcher*, wooden spoon*

Note: * Denotes items that were inaccessible during the interrupted chain procedure

A stopwatch was used to ensure the accuracy of reinforcer access time and delay-to-prompt intervals. An additional stopwatch was used to record the length of each PECS and manual sign training session.

Design

An alternating treatments design was used to compare the total number of training blocks and the total amount of training time to teach mands for preferred items using manual sign and PECS. Generalization of mands acquired using PECS across communicative partners and settings was evaluated, as was the emergence of untrained tacts and intraverbals for PECS. An alternating treatments design was also used to compare the total number of training blocks to teach mands for items needed to complete chained tasks using manual sign and PECS for Louie. Following this training, the generalization of mands acquired using PECS across communicative partners and settings was evaluated, as was the emergence of untrained tacts and intraverbals.

Training sessions were conducted at least three times weekly. Half of each session was allocated for PECS training and the other half was allocated for manual sign training. The order in which PECS and sign training took place during each session was randomly determined, with the stipulation that the training of one communication form first did not occur for more than three consecutive sessions. Communication binders were not available during sign training sessions, and the instructor was prepared to physically block any emission of a manual sign that might have occurred during PECS training, although none did. If a participant attained mastery criterion for one response modality but scored 50% correct per training session or be-

low for the other response modality for two consecutive sessions, training for the second response modality was discontinued.

Procedure

Teaching Mands for Preferred Items. Preferred items were identified via the administration of the Reinforcer Assessment for Individuals with Severe Disabilities (RAISD), which was conducted in interview format with direct care staff at the developmental training center. Ten items were selected on the basis of the results of the interview for each participant; those items were then included in a multiple stimulus preference assessment without replacement (see DeLeon & Iwata, 1996). Each participant would be taught five mands for preferred items using PECS and five mands for preferred items using manual sign.

Baseline. During baseline, each participant's ability to mand for five preferred items using PECS was assessed, as was his or her ability to mand for five preferred items using manual sign. Skills consistent with Phase 3 of PECS and manual sign training (as will be described below) were evaluated. Each participant had access to his or her three-ring binder during the PECS baseline condition, but not during the baseline condition for manual sign. The binder contained five photographs of preferred items and five photographs of distracter items. Baseline for both response modalities consisted of three blocks of ten trials, with mands for each of the preferred items being assessed twice per trial block. The presentation of a preferred item marked the onset of a trial, after which the participant was allotted 5 s to either exchange the picture or emit the correct sign. The next item was then presented. No feedback or prompts were delivered during baseline.

Generalization probes. Generalization of mand skills consistent with mastery of Phase 3 was assessed for mands acquired using PECS across both settings and communicative partners. Generalization probes occurred prior to training and immediately following mastery of five mands. Probes were conducted in one 10-trial block, with a score of 80% or higher being indicative of generalization across settings and communicative partners. The generalization setting was the kitchen of the facility, and the communicative partner was a person known to the participants who was not present during any other training or test sessions.

PECS training. Participants were taught to mand for five items using PECS. Training was conducted in 10-trial blocks. PECS training was performed largely according to the procedures developed by Frost and Bondy (2002). PECS was designed to include six phases; in this study, skills consistent with the first three phases were targeted. The objective of Phase 1 is for the participant to hand a picture of a preferred item to the instructor while in the presence of a preferred item. Before beginning the trial block, the instructor allowed the participant access to a preferred tangible item for 2 s or provided a small piece of a preferred consumable item to assess the item's current reinforcing value. If the participant consumed the item or manipulated the item, the instructor took the tangible item back and began the trial block. If the individual did not consume the edible or gave the item back, the instructor identified a more preferred item by repeating the above steps. The presentation of one of the five preferred items marked the onset of each instructional trial. The instructor showed the item to the participant and as the participant reached for the item, the instructor opened her hand and physically prompted the participant to pick up the picture, reach toward the instructor and place the picture in the open hand. Once the picture was released into the instructor's hand, the item was immediately delivered and the instructor provided feedback such as "I want (*item*)" or "(*item*).". The participant was given 5–15 s to manipulate tangible items, and however long was necessary for the participant to consume edible items. Physical prompts were faded in accordance with a most-to-least prompting system that ranged from full physical guidance to a partial physical prompt, such as a gentle tap on the participant's elbow. An intertrial interval of 5 s separated each trial. If an error oc-

curred during the trial, an errorless back step procedure (Frost & Bondy, 2002) was used, in which the instructor went back in the sequence to the last step correctly completed and provided more assistance than the previous trial to complete the sequence. Instructional trials were initially presented in a mass-trial format (i.e., ten trials for one preferred item). As the participants mastered the mands, the five preferred items were eventually presented in a random order throughout a training block. Phase 1 of PECS was mastered when a participant manded independently for all five items with 100% accuracy per block. (It should be noted that the PECS manual explicitly recommends the use of an additional instructor during Phase 1 of PECS training, one to entice and deliver the reinforcer, and the other to deliver and fade the physical prompts.)

The objective of Phase 2 is for the participant to go to his/her communication binder, pull off the picture of the preferred item, travel to the instructor, gain the instructor's attention and release the picture into the instructor's hand. Thus, the distance between the learner and the communication binder and the learner and the instructor is to be increased. The instructor assessed the reinforcing value of each item prior to each trial, as was done in Phase 1. The presentation of a preferred item marked the onset of each trial. Once the participant placed the picture of the preferred item in the instructor's hand, the item was delivered, along with feedback identical to that used during Phase 1. If needed, the instructor provided physical guidance to remove the picture from the book only after the participant initiated by reaching for the item. The instructor systematically faded physical prompts until the participant was able to remove the picture from the book and exchange the picture independently. Once the participant was able to remove the picture from the binder and exchange the picture independently 9 out of 10 times during a trial block, the distance between the instructor and the participant increased. The error correction procedure used in Phase 2 was identical to that used in Phase 1. Once the participant independently manded for the five preferred items on 9 out of 10 trials per block, the distance between the individual and the book was increased. The instructor began this training by remaining close to the participant and moving the book a few inches away from the participant. Over several trials, the book was moved further away from the participant so the participant was

required to get up and walk to the book. Once the participant was able to independently travel to the book across the room and complete the mand sequence on 9 out of 10 trials per block, the instructor moved away from the binder so that the participant was required to travel to the book and to the instructor in order to make the exchange. Phase 2 was mastered when the participant independently traveled to both the binder and the instructor with 90% accuracy within a trial block.

The objective of Phase 3 of PECS is for the participant to mand for a desired item by traveling to the communication binder, selecting the appropriate picture from an array, and traveling to the communicative partner and exchanging the picture. Participants were first taught to discriminate between pictures of preferred and distracter items. The presentation of a preferred item marked the onset of each trial. As soon as the participant reached for the correct picture, verbal feedback was provided. Once the picture was exchanged, the instructor delivered the corresponding item. If the participant reached for the picture of the distracter item, no verbal feedback was given and the nonpreferred item was delivered. If the participant's reaction to the distracter item was negative, the four-step error correction procedure described within the PECS manual was utilized. The four-step error correction procedure consisted of a model, prompt, switch and repeat. The model consisted of the instructor showing or tapping the target picture. The prompt consisted of the instructor holding an open hand near the target picture and physically or gesturally prompting the participant to give the correct picture. During the switch, the instructor asked the participant to complete a simple task in the participant's repertoire (i.e., gross motor imitation) or turned over the binder for 2 s. After the switch, the instructor repeated the trial by enticing the participant with both items. If the individual gave the correct picture, the instructor delivered the item and feedback. If the participant exchanged the incorrect picture again, the instructor cycled through the error correction procedure again. The mastery criterion for this portion of Phase 3 was for the participant to exchange the correct picture 9 out of 10 times within a trial block and to exchange the correct picture 9 out of 10 times within a trial block when the binder and the communicative partner were more than two feet from the participant. Participants were next taught to discrimi-

nate between pictures of preferred items. This training was conducted in a manner identical to that for teaching participants to discriminate between preferred and distracter items.

(The reader is referred to Frost & Bondy, 2002 for a more detailed description of the PECS protocol.)

Manual sign training. Manual signs were taught in three phases that were intended to approximate the three phases of the PECS protocol as closely as possible (Chambers & Rehfeldt, 2003). Participants were taught to mand for five preferred items using manual sign. The five signs that were taught to each participant were simplified versions of the signs in American Sign Language. The signs were simplified according to the fine motor ability of each participant and the complexity of each sign. All of the signs were considered to be equivalent in response effort and difficulty and consisted of either one-step or two-step movements.

Phase 1 of manual sign training consisted of teaching the participant to emit the correct sign within 5 s of the presentation of the preferred item, which marked the onset of each instructional trial. If the participant correctly emitted the sign, the item was immediately delivered, along with feedback such as "(item)." If the participant emitted an incorrect sign or did not respond, the instructor provided a model of the correct sign. If the participant emitted an incorrect sign or failed to respond within 5 s after the instructor modeled the correct sign, a physical prompt was provided. Prompts were gradually removed as the participant acquired the signs. Instructional trials were initially presented in a mass-trial format (i.e., 10 trials for one preferred item). As the participants mastered the signs, the five preferred items were eventually presented in a random order throughout a training block. The mastery criterion for this phase was 100% accuracy per trial block, with each of the five items presented twice per block.

Although a training protocol for Phases 2 and 3 was established, none of the participants mastered Phase 1 of manual sign training. Thus, Phases 2 and 3 were not conducted.

Teaching mands under transitive CEO control. Louie was taught three mands under transitive CEO control using PECS and three mands under transitive CEO control using manual sign. The items specified in each mand were inaccessible items that were needed to complete a chained task. This training was implemented

following the conclusion of teaching mands for preferred items.

Baseline. During baseline, Louie's ability to mand for three inaccessible items needed to complete a chained task using PECS was assessed, as was his ability to mand for three items needed to complete a chained task using manual sign. One chained task was assigned to PECS while a second chained task was assigned to manual sign. The chained task used for PECS training was making instant pudding, where Louie was taught to mand for milk, a whisk, and a mixing bowl. The chained task used for manual sign was making iced tea, where Louie was taught to mand for a cup, a wooden spoon, and a pitcher. Louie had been taught these tasks prior to the study and was considered proficient in performing them, as evidenced by 100% accuracy on both tasks for three consecutive trials.

All of the items needed to complete the task were presented on a table except for the items shown in Table 2, which were inaccessible and not visible to Louie. During the task assigned to PECS (making pudding), three pictures of items needed to complete the chained task and three pictures of distracter items were available in his binder. When he reached the step in the task for which the missing item was needed, he was allotted 5 s to give the instructor the correct picture of the necessary item. Baseline for manual sign was identical except that Louie was given 5 s to emit the correct sign for the missing item needed to complete the task that was assigned to sign (making iced tea). The binder was not available during this task. No feedback or prompts were delivered throughout baseline, nor were the needed items ever delivered. Rather, the instructor completed the step in the chain after obtaining the missing item, at which point the participant was allowed to continue with the task. One trial block, in which Louie had the opportunity to mand for each item twice, was presented for both PECS and manual sign.

Generalization probes. Generalization of mands under transitive CEO control across settings and communicative partners was assessed for mands acquired using PECS in the kitchen at Louie's group home. Probes were conducted in a manner identical to baseline test trials. The communicative partner was known to Louie but had not served in this role previously. Generalization probes occurred prior to training and immediately following the mastery of mands for three missing items.

Training. During training, all of the items needed to complete the chained task were available on the table except for the three items shown in Table 2, which were inaccessible and not visible. When the participant reached the step in the task for which the missing item was needed, a correct mand for the missing item resulted in the presentation of the missing item along with feedback from the instructor, such as stating the name of the item. An incorrect response or no response resulted in a gestural prompt for the correct picture during PECS training, while an incorrect response or no response resulted in a modeled prompt during sign training. If Louie did not imitate the instructor within 5 s, a physical prompt was provided. Prompts were gradually removed over the course of training. Mastery criterion for each communication modality was 100% accuracy for two consecutive trial blocks.

Test Probes for Functional Independence of Verbal Operants

Prior to teaching mands for preferred items and mands under transitive CEO control, test probes were conducted to determine whether PECS or sign would be used to tact the items that would be used in mand training. Probes were also conducted to determine whether PECS or sign would be used to engage in intraverbal responding about those same items. Tact and intraverbal test probes involving preferred items were conducted in one 10-trial block each for each communication modality. Tact and intraverbal test probes involving items needed to complete the chained tasks for Louie were conducted in one 6-trial block each for each communication modality. The order of trials throughout all blocks was randomly determined. On tact test trials, the instructor held up the item and asked, "what is this?" (Because both the instructor's question and the presence of the item could have exerted antecedent control over responding, tact trials may also be regarded as intraverbals/tact trials.) On intraverbal test trials, the instructor presented a verbal antecedent stimulus (i.e., "tell me something that you read") (see Table 3). No feedback or prompts were delivered on tact or intraverbal test trials. For both the tact and intraverbal probes, the participant was allotted 5 s to emit the correct response using either PECS or manual sign. When untrained tacts and intraverbals were tested using PECS,

Table 3
Antecedent Verbal Stimuli and Correct Responses for Intraverbal Test Probes

Discriminative stimulus	Correct responses
"Tell me something that is white."	Milk
"Name something you mix with."	Whisk
"What do you mix things in?"	Mixing bowl
"What do you drink from?"	Cup
"Tell me something you stir with."	Wooden spoon
"What do you pour with?"	Pitcher
"Tell me something you drink."	Lemonade, soda
"Tell me something you like to eat."	Cookie, cupcake, M&M's
"What do you read?"	Book
"Tell me something you look through."	Magazine
"What do you do with paper & pencil?"	Write
"What do you look at?"	Baseball cards
"Tell me something you listen to."	Music
"Tell me something you eat with a spoon."	Applesauce
"Tell me something you shuffle."	Deck of cards
"Tell me something you put together."	Puzzle
"What do you like to play?"	Memory game, Connect Four
"What do you put on a string?"	Beads

the participant's communication book was available to him or her, and the pictures of all of the training items were contained within. The communication book was not available on the manual sign tact or intraverbal test probes.

The test probes were repeated following mastery of mands for preferred items and mands under transitive CEO control (for Louie). These test probes were identical to those conducted before training. Also at this time a second block of tact and intraverbal test trials was presented, which were identical to the first block with the exception that generalized conditioned reinforcement (i.e., social feedback) was provided for correct tacts or intraverbals. Conducting test trials in the absence of reinforcement permitted for the evaluation of whether the tacts or intraverbals had emerged in the absence of training, while delivering generalized conditioned reinforcement for correct responses allowed for the emergent responses to meet Skinner's (1957) definition of the tact and intraverbal, both of which are held to be maintained by generalized conditioned reinforcement.

Dependent Measures and Interobserver Agreement

Dependent measures were the percentage of correct trials per block for both PECS and manual

sign training for preferred items, the percentage of correct trials per block for mands under transitive CEO control for Louie, and the percentage of correct trials per block for tact and intraverbal test probes. Reliability was established by comparing two observers' independent documentation of the accuracy on each trial for each participant. An agreement was defined as both observers recording the same instance of behavior as either a correct response or an incorrect response. Disagreement was defined as one observer recording an occurrence of a correct or incorrect response when observer agreement was calculated on 41% of the sessions for mands under transitive CEO control. The mean interobserver agreement for mands under transitive CEO control for all conditions was 100%.

RESULTS

MANDS FOR PREFERRED ITEMS USING PECS AND MANUAL SIGN

Louie

Baseline. Figure 1 shows that Louie did not mand for preferred items using PECS or sign during baseline in either the classroom or the kitchen at the developmental training center.

Figure 1. The percentage of trials correct per block during baseline, training, and generalization probe sessions for mands for preferred items for Louie.

Pretest probes for tacts and intraverbals. Figure 2 shows that Louie did not emit tacts or intraverbals using either PECS or manual sign prior to training.

Training. As shown in Figure 1, Louie met mastery criterion for Phases 1–3 of PECS in a total of 34 trial blocks. Phase 1 required 2 blocks for mastery, Phase 2 required 4 blocks for mastery, and Phase 3 required 28 blocks for mastery. A total of 236 min was required for Louie to master the entire three phases. Phase 1 required 15 min of training time, Phase 2 required 34 min of training time, and Phase 3 required 187 min of training time. Figure 1 also shows that Louie scored 90% on the generalization probe for PECS conducted immediately following training. Thus, Louie demonstrated the generalization of mands for preferred items using PECS across settings and communicative partners.

Manual sign training was discontinued after the 67th training block due to the fact that PECS had been mastered and Louie's manual sign scores fell below 50% for at least two consecutive sessions. Louie's total training time for manual sign before discontinuation of training was 365 min and 62 trial blocks for Phase 1 of sign training.

Emergence of untrained tacts and intraverbals. Figure 2 shows that following

PECS training Louie scored 90% on the nonreinforced block and 100% on the reinforced block of test probes for untrained tacts. Louie scored 40% on both the nonreinforced and reinforced block of test probes for untrained intraverbals. Thus, Louie showed the emergence of untrained tacts for the items used in mand training, using PECS, following the mastery of Phases 1–3 of PECS. On all test trials for both tacts and intraverbals, Louie pointed at the picture of his choice rather than exchanging it with the experimenter.

Robin

Baseline. Figure 3 shows that Robin did not mand for preferred items using PECS or sign during baseline in either the classroom or the kitchen at the developmental training center.

Pretest probes for tacts and intraverbals. Figure 4 shows that Robin did not reliably emit tacts or intraverbals using either PECS or manual sign prior to training.

Training. As shown in Figure 3, Robin met mastery criterion for Phases 1–3 of PECS in a total of 15 trial blocks. Phase 1 required 1 block for mastery, Phase 2 required 7 blocks

Figure 2. Test probes for tacts and intraverbals prior to and following PECS training for Louie.

for mastery, and Phase 3 required 7 blocks for mastery. A total of 160 min was required for Robin to master the entire three phases. Phase 1 required 12 min of training time, Phase 2 required 80 min of training time, and Phase 3 required 68 min of training time. Figure 3 also shows that Robin scored 90% on the generalization probe for PECS conducted immediately following training. Thus, Robin demonstrated the generalization of mands for preferred items using PECS across settings and communicative partners.

Manual sign training was discontinued after the 25th training block due to the fact that PECS had been mastered and Robin's manual sign scores fell below 50% for at least two consecutive sessions. Robin's total training time for manual sign before discontinuation of training was 205 min and 20 trial blocks for Phase 1 of sign training.

Emergence of untrained tacts and intraverbals. Figure 4 shows that following PECS training Robin scored 10% on the nonreinforced block and 0% on the reinforced block of test probes for untrained tacts. It is worth noting that Robin emitted unintelligible vocalizations on tact test trials, which had not been observed at any other time during the

study. Robin scored 100% on both the nonreinforced and reinforced block of test probes for untrained intraverbals. Thus, Robin showed the emergence of untrained intraverbals involving the items used in mand training, using PECS, following the mastery of Phases 1–3 of PECS. On all test trials for both tacts and intraverbals, Robin pointed at the picture of her choice rather than exchanging it with the experimenter.

Bonnie

Baseline. Figure 5 shows that Bonnie did not mand for preferred items using PECS or sign during baseline in either the classroom or the kitchen at the developmental training center.

Pretest probes for tacts and intraverbals. Bonnie did not emit tacts or intraverbals using either PECS or manual sign prior to training.

Training. As shown in Figure 5, Bonnie mastered Phase 1 of PECS in 1 training block and 6 min. Phase 2 of PECS was discontinued after block 29 due to her unwillingness and difficulty traveling to the communicative partner and communication binder. PECS and sign training were discontinued after block 53 after staff expressed concern about Bonnie's increasing

Figure 3. The percentage of trials correct per block during baseline, training, and generalization probe sessions for mands for preferred items for Robin.

aggression. A medical evaluation conducted at this time suggested that Bonnie was suffering from early-onset dementia. Phase 1 of manual sign training was not mastered.

MANDS UNDER TRANSITIVE CEO CONTROL

Louie

Baseline. Figure 6 shows that Louie did not mand for items needed to complete a chained task using PECS or sign during baseline in either the kitchen at the developmental training center or the kitchen in his group home.

Pretest probes for tacts and intraverbals. Louie did not emit tacts or intraverbals for the items to be used in the interrupted chain procedure using either PECS or manual sign prior to training.

Training. As shown in Figure 6, Louie met mastery criterion for mands under transitive CEO control using PECS in 17 training blocks. At this time, manual sign training was discontinued. Figure 6 also shows that Louie scored

83% on the generalization probe for PECS conducted immediately following training. Thus, Louie demonstrated the generalization of mands under transitive CEO control using PECS across settings and communicative partners.

Emergence of untrained tacts and intraverbals. Louie did not emit tacts or intraverbals using PECS, scoring 0% on all test blocks. On all test trials for both tacts and intraverbals, Louie pointed at the picture of his choice rather than exchanging it with the experimenter.

DISCUSSION

The results of this study suggest that for two participants, Louie and Robin, teaching mands for preferred items was effective using PECS. For both participants, PECS was acquired in a shorter amount of training time and the communicative responses readily generalized to novel settings and communicative partners than mands acquired using manual sign. However, neither participant had completed a for-

Figure 4. Test probes for tacts and intraverbals prior to and following PECS training for Robin.

Figure 5. The percentage of trials correct per block during baseline, training, and generalization probe sessions for mands for preferred items for Bonnie.

mal assessment prior to the study to determine whether or not they had the prerequisite skills necessary to be successful with manual sign training. Moreover, with so many variables, such as the prompting and prompt reduction techniques differing between the two procedures, it is difficult to set up a fair comparison of PECS versus manual sign. Thus, while these results do not necessarily suggest that PECS was more effective, they do nonetheless add to

Figure 6. The percentage of trials correct per block during baseline, training, and generalization probe sessions for mands under transitive CEO control for Louie.

the body of evidence for the efficacy of PECS in establishing functional communication skills in individuals with severely limited verbal repertoires (e.g., Chambers & Rehfeldt, 2003; Charlop-Christy et al., 2002). Importantly, this seems to be the case for adults with little history of systematic instruction and limited imitation skills. A likely reason that manual sign instruction was not effective in this study is that modeled prompts were used throughout sign training, which may not have been appropriate given the participants' limited imitation repertoires. What seems vital is a prior assessment and identification of an individual's skills in a number of areas when determining which form of alternative communication system to implement. For instance, fine motor skills, picture discrimination, visual acuity and imitation skills may all be important factors in determining the most appropriate system. Future research should explore the prior assessment of the prerequisite skills necessary for each system (Gregory, DeLeon, & Richman, 2005).

Another reason that PECS may have been more readily acquired is that PECS is a selec-

tion-based communication system. With PECS, participants are only required to discriminate between the pictures and exchange the correct picture for the preferred item, regardless of the item. Manual sign, in contrast, is a topography-based communication system, meaning that the participants must learn a different response topography for each item. For the participants in this study, the recall of the correct manual sign for each item may have been more challenging than the recognition of the correct picture (Chambers & Rehfeldt, 2003). Another reason that PECS may have been more readily acquired may be due to the fact that the communication binder was available during PECS sessions and may have served as a discriminative stimulus (in addition to the preferred items) for exchanging the pictures, whereas in manual sign training, no such additional discriminative stimuli (other than the preferred items) were present.

Following mastery of mands for preferred items using PECS, Louie met criterion for the emergence of untrained tacts and Robin met criterion for the emergence of untrained intraverbals. These results differ somewhat

from results from other studies showing that training in one repertoire does not necessarily produce concomitant changes in another repertoire (Lamarre & Holland, 1985; Hall & Sundberg, 1987; Sigafoos et al., 1989; Watkins, Pack-Teixeira, & Howard, 1989). An explanation for this finding is based upon the acknowledgement that PECS training establishes multiply-controlled verbal operants (Bondy et al., 2004): When the mands are initially trained, the responses are actually under the control of both establishing operations and prior antecedent stimuli, those being the respective preferred items present on a given trial, such that the responses trained may actually best be regarded as "mand-tacts" (Bondy et al., 2004). Therefore, tacts and intraverbals may have emerged as a result of the multiple stimulus control established during PECS training. PECS may thus be an efficient means of teaching verbal operants to individuals with severely limited verbal repertoires. Interestingly, during the test probes for the emergence of untrained tacts and intraverbals using PECS, Louie and Robin used a different topography than that which had been established during mand training. Rather than exchanging pictures, as they had been directly taught during mand training, both pointed at a picture in their binder on both tact and intraverbal test trials. This suggests that the emergent tacts and intraverbals were indeed under different sources of stimulus control than the previously established mands.

The second portion of this study used an interrupted chain procedure to establish mands under transitive CEO control for Louie. Teaching Louie to mand for items needed to complete the chained tasks ensured that the mands were exclusively under the control of establishing operations and not prior antecedent stimuli. Such a repertoire was establishing using PECS for Louie; moreover, the mands generalized across settings and communicative partners. However, after teaching Louie to mand for preferred items using PECS, it is somewhat surprising that so much additional mand training within the context of the chained tasks was necessary, as PECS as a communication system had already been acquired. It is possible that the different sources of control in each context may account for this discrepancy: In teaching mands for preferred items, responding may have been under the control

of both establishing operations and the preferred items, but in teaching mands for items needed to complete the tasks, responding was likely exclusively under the control of establishing operations. In addition, individuals with more significant levels of mental retardation may simply require more extensive training in manding for items out of view than is currently delineated in the PECS training protocol. Interestingly, following the training of mands under transitive CEO control for Louie, tacts and intraverbals did not emerge, thus supporting Skinner's (1957) notion of the functional independence of the verbal repertoires and results from previous studies (Lamarre & Holland, 1985; Hall & Sundberg, 1987; Sigafoos et al., 1989; & Watkins et al., 1989). It is quite possible that neither untrained tacts or intraverbals emerged because the repertoire trained in this portion of the study was not multiply controlled.

As previously noted, the major limitation of this study concerns the feasibility of comparing PECS and manual sign, given that different prompting and prompt reduction strategies were used for the two modalities. Certain prompting hierarchies may be more effective for certain learners, thus making instruction in one communication system more effective than instruction in the other. A dilemma facing clinicians is the fact that a comprehensive training manual, such as that which has been established for PECS, is not available for manual sign, thus leaving many of the components of training up to the judgment of the clinician. Future research should focus on the identification of prerequisite skills that appropriate candidates for each communication system should have, efforts that have already been initiated by Gregory et al. (2005). Future research should also continue to focus on the degree to which untrained operants will indeed emerge following training in either modality (Bondy et al., 2004).

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