CASE REPORT

A Compensatory Counting System: Academic Skill Training

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Basic counting skills are prerequisites to a variety of academic and vocational tasks as well as community survival skills (Baroody & Snyder, 1983; Spradlin, Cotter, Stevens, & Friedman, 1974). Counting is often the only math skill required in jobs where persons with mental retardation seek employment (Chandler, 1978; Easterday, 1987). If persons with mental retardation can be taught some basic math skills, such as functional counting, they will have the competence necessary for wider job opportunities and greater independence in the community (Baroody, 1986b; Baroody & Snyder, 1983; Chandler, 1978; Spradlin et al., 1974).

Sildington, Frank, and Carson (1992) found in their study of 142 young adults with mental retardation that one third to one half were competitively employed in the community in service and labor jobs after high school. In competitive employment, workers who cannot count place hardship on their coworkers without disabilities; for example, the coworker without disability cannot ask, "How many...are there?"; "Could you bring me six of those...?"; or "After you clean those three rooms, could you..." The coworkers without disabilities have to adapt or complete the task themselves, thus increasing their workload.

Occupational therapy practitioners can adapt the working environment, use adaptive equipment, and modify the behavior of coworkers without disabilities to provide success for adults who have lower functioning. Occupational therapy practitioners can also use all these same adaptations in the school environment to teach students with disabilities the academic skills they will need in the workplace. Education and transition individualized education programs should expand, not restrict, the range of occupational choices available to a student (Szynanski, 1994). Counting is a skill that enhances one's ability to be useful and productive in any occupation.

Counting typically requires the use of a series of symbols that depict abstractions that persons with mental retardation do not easily understand (Bartetta-Lorton, 1976). Object counting, as proposed by a number of authors (see review by McEvoy, 1989), is a complex process. It involves rote counting in correct sequence (i.e., one-to-one correspondence between the number name and the counting object), recognizing that the last number named is the total, and remembering the objects that have been counted (Fazio, 1994). Developmentally, it takes approximately 1 year from the time that a child begins to recognize number words to the time that he or she learns that number words refer to a meaningful counting concept (Wynn, 1992).

Because counting is a complex process and demands
a considerable amount of precision, there are numerous ways a child can miscount the objects in a set, such as counting objects twice, skipping items to be counted while scanning, or counting out of sequence (Baroody, 1986b; McConkey & McEvoy, 1986; McEvoy & McConkey, 1990). Not surprisingly, children with mental retardation were found to show a considerable delay in basic (rote and object) counting competencies (Baroody, 1986b; McEvoy & McConkey, 1991; Spradlin et al., 1974). McConkey and McEvoy (1986) found that only 50% of the teenagers who had moderate mental disabilities and had received an average of 10 years of schooling could rote count to 20 or object count to 10 accurately and reliably. Porter (1993) studied children with severe mental disabilities and found that only those scoring the highest on a picture vocabulary test (i.e., 20% of the subjects) were able to demonstrate understanding of what constitutes a correct count.

Counting accuracy for children with mental retardation deteriorates considerably for sets larger than 5 and is accompanied by a marked increase in the number of verbal and correspondence errors (Baroody, 1986b; McEvoy & McConkey, 1990, 1991; Spradlin et al., 1974). A tendency exists to underestimate quantities of objects due to an incomplete knowledge of counting numbers of "teens" (i.e., 13, 14, 15) and "decades" (i.e., 20, 30, 40). Researchers have also noted difficulties in identifying numbers with more than one digit (Baroody, 1986b; McEvoy & McConkey, 1990, 1991; Spradlin et al., 1974). Some possible explanations of the impairments in object counting for children with mental retardation include delay in acquisition of the number-word sequence, auditory sequential memory deficits, low efficiency in basic information processing, conceptual deficit, and incoordination of verbal and visuoperceptual motor skill (Baroody, 1986b; McEvoy & McConkey, 1990, 1991).

In the past decade, there has been growing interest in learning and development of basic counting skills in children with mental retardation (Baroody, 1986a; Baroody & Snyder, 1983; Marx, 1989; McEvoy & McConkey, 1990, 1991; Spradlin et al., 1974). However, few studies have demonstrated effectiveness of the suggested remedial strategies to improve the counting skills in this population. Baroody and Ginsburg (1984) examined the effectiveness of an individualized tutoring program (11 hours, 3–5 times a week for 7–8 weeks) on counting and number skills training in 38 children with mental retardation. The curriculum activities were based on counting games. The results showed an improvement in extending the children's sequence of rote counting. However, no transfer of this learning to object counting was demonstrated. With a similar approach (table-top games with special dice over a 6-week period), McConkey and McEvoy (1986) demonstrated an improvement in basic counting skills in 24 children with moderate mental retardation. However, no generalization of results were reported.

Roles of Occupational Therapists

In school systems, occupational therapists may assist special education teachers in developing alternative educational methods and in modifying their teaching strategy to enhance a student's performance in the regular classroom, home, community, and vocational environments (Broller, Shepherd, & Markley, 1994). Occupational therapy interventions include focusing on cognitive and prevocational skills training (Crowe & Kanny, 1990; Sorenson, 1993).

The first author designed a compensatory counting system for a 13-year-old student with mental retardation to enhance his ability to meet his educational goals. The system involves training in a graded motor planning sequence of four steps and adaptation in the form of an object count of five as the basic "set," or framework. This article describes the steps of the compensatory counting system and exemplifies its use with a case report.

The Compensatory Counting System

**Step 1: Visuomotor Placing**

This step involves matching and counting. Twenty numbers of multiples of five (5, 10, 15, 20...100) are written on a long strip of paper about 4 in. wide. This strip is placed on a table. The student is shown a handwritten number of a multiple of five (e.g., 15) on a piece of paper. The student is asked to match the handwritten number with a number on the number strip and to place a marker on the matched number (in this case, the student places a marker on the number 15).

The student then performs a series of counting tasks beginning with counting out five objects and placing them directly below the first number, which is 5. He or she then counts five more objects and places them below the number 10 and repeats this procedure for the number 15. The student recognizes that the number 15 has a marker on it and discontinues the sequence because there are now 15 objects altogether on the table (see Figure 1).

Accuracy and error recognition are emphasized during this step. Immediate feedback to rectify errors is given. Recognition of what a set of five objects looks like and the awareness of accuracy (which includes recounts of the five objects below each number) are the goals of this step. This step can also serve as an assessment of the student's ability to successfully follow the next steps.
Figure 1. The sequence used in Step 1, Visuomotor Placing.

**Step 2a: Sequential Patterning**

*Part I.* Twenty numbers of multiples of five are each written on 20 4-in. cards. These cards stacked in order with the numbers facing up (the first card is 5, the second card is 10, etc.). The student is presented with a handwritten number of a multiple of five (e.g., 25) on a piece of paper and asked to find the matching number from the stack of cards. The student takes the first card from the stack and places it face down on the table to create a new pile. He or she continues transferring cards from the stack to the new pile, one at a time, until the matching number is found. The purpose of this step is to reinforce and extend the number-matching skills training in Step 1. This step also facilitates the learning in Part II because the number of cards in this new pile corresponds to the number of counting trials to be completed.

*Part II.* After the student creates the new pile of cards (made up of five cards in this case because the target number is 25), the teacher flips over the whole pile. The student then counts five objects from cardboard box A (see Figure 2). He or she then recounts them before placing them into cardboard box B. The student turns over the top card of the pile and places it face down on the table to create a new stack. This process is repeated until all the face-up cards are turned over.

Error recognition is not possible in this step because the objects are not in the student's visual field where they can be recounted in their groups of five. Additionally, the numbers of cards presented to the student in the pile are set so as to match the number of counting trials from box A to box B. Consistent motor sequential pattern use will allow a student to successfully learn to move objects from one container to another. If when attempting Step 2a, the student exhibits confusion, randomly turns over the cards, or frequently counts random numbers without regard to numerical sequence, Step 2b is introduced.

*Step 2b: Sequential Patterning*

This step provides a longer motor sequencing pattern to attain the goal of providing greater accuracy in the sequence of card turning. A sequence pattern with more than one step can provide increased sensory input. This sensory input emphasizes the importance of the card turning step and assists in the development of sequential memory skills.

*Part I.* Similar to Part I of Step 2a, the student is asked to match a handwritten number of a multiple of five (e.g., 30) on a piece of paper from a stack of cards in numerical order. The purpose of this step is to reinforce and extend the number-matching skills training of Step 1.

*Part II.* A stack of cards (six in this case; the number of objects to be counted equals 30) are placed in order, with each card number face down (i.e., the first card is 5, the second card is 10, the sixth card is 30). The purpose of the numbers facing down is to reduce visual confusion during counting. The student turns over the top card (which is 5), and places it face up to the left of the stacked cards (see Figure 3). He or she then counts five objects from box A and recounts them while placing them into box B. The student turns the face-up card over to create a pile on the far left. This process is repeated until all the cards from the right are moved sequentially to the left, and the counting is completed.

*Step 3: Counting Concept*

Numbers are written as a multiple of five plus another number of less than five (e.g., 47 would be written as 45 + 2) because the student does not have “counting up”...
Step (iii)
Recount the 5 objects as they are placed into a new box.

Step (ii)
Count 5 objects

Step (iv)
Place the card face down in a pile to the far left.

Step (i)
Turn over top card and place face up to the left of the pile.

Figure 3. The sequence used in Step 2b, Sequential Patternning.

Step 4: Functional Use

This step transfers the student’s counting skills from the cards to a more socially acceptable compensatory device, the hand-held calculator. The student is asked to turn the calculator on and check to see that zero is showing (if not, turn off the calculator and turn it on again). He or she is given a handwritten number on a piece of paper (e.g., 50 + 3). The student is instructed to count out objects as follows:

1. Count out five objects from box A.
2. Recount the five objects as they are placed into box B.
3. Press the “5” button on the calculator.
4. Check that the number 5 is displayed on the screen. If not, press the “clear entry” button (C or CE) and press 5 again. It may be necessary to avoid teaching the student to use the “clear all” button (CA or AC) because accidental pressing of this button will delete the cumulative score.
5. Press the “plus” button (+).
6. Check the display against the first handwritten number (in this case, 50).
7. Repeat steps 1 through 6 until the displayed number on the calculator matches the handwritten number.
8. Look to see whether the handwritten number has a + after it (e.g., 50 + 3). Place 3 more objects in the box.

The skills required for a student to use the compensatory counting system are: (a) evidence that 4- to 5-step motor sequencing patterns can be learned and retained over a short period, which can be evaluated through some daily living or vocational tasks, such as making a sandwich or making a photocopy; (b) the ability to match correctly the 20 numbers of a multiple of five; and (c) the ability to show consistent one-to-one correspondence to number 5 as separate counts.

Case Report

This compensatory counting system was developed for a 13-year-old student with mental retardation who attended 7th grade in a public middle school. The student’s intelligence quotient was 52. For two semesters, he attended the school’s “essential skills” program, an individualized special education program that provided functional life skills training for students who had shown poor response to traditional academic classes. The student’s individual education plan objectives included counting training, accurate recognition of time, and functional use of money.

The student was highly motivated to work independently in the school cafeteria. One of the tasks in this site was to count pieces of fruit that were sent to all the schools in the district. He could successfully perform all assigned tasks except counting, which a peer performed for him when necessary. Because the special education teacher had exhausted all academic methods to teach this student to count accurately past 10, the student was referred to occupational therapy for training in counting, with the objective of independent performance of the cafeteria task.

Occupational Therapy Evaluation

Evaluation of the student’s functional math skills indicated that he was able to rote count from 1 to 10 accurately and consistently and that he could recognize, name, and write numbers up to 9. Occasionally, he could recite the correct sequence up to 23. In object counting, the student was able to accurately count from 1 to 10 consistently for pennies, which were placed in a money roll, but this skill was not generalized to other counting tasks. The student consistently matched two-digit numbers correctly; however, accuracy in reading them was inconsistent. He could also copy letters and numbers with accurate spacing and sequence, and he could read and write his name.

Intervention

The student received individual occupational therapy for 30 min, 2 days a week. The compensatory counting system was developed during the first few sessions. The spe-
cial education teachers practiced the system with the student daily for 20 min. The occupational therapist provided collaborative consultation to the teachers throughout the training process.

Progress in Training

The student mastered Step 1 in a 2-week period. He did not attain Step 2a because he experienced difficulty incorporating the card turning step into his counting sequence. As a result, Step 2b was implemented. The student required 4 consecutive weeks of 20 min of practice per day to complete five consecutive trials accurately. Step 3 was introduced in the school cafeteria. Within three trials, supervision was faded to observation from a distance. Success on five consecutive trials with Step 3 occurred within 2 weeks, with 20 min of practice each day. The student achieved Step 4 quickly, with successful transfer from the cards to the calculator in two 20-min sessions.

Reevaluation

After the 10-week training in the use of the compensatory counting system, the student’s functional math skills were reevaluated. He independently counted objects presented to him with 100% accuracy on 34 functional counting tasks in different natural environments (e.g., the school cafeteria [counting pieces of fruit], the school office [counting attendance lists], the classroom [counting sets of various amounts of items to be distributed to students in home economics or art classes]). Distractions were not manipulated in any way. Observation and recounting of these tasks was performed by one teacher and the first author over a 2-week period. A 100% interrater reliability was achieved.

Of note, the student’s accuracy in performance consistently occurred only when objects were being counted for a reason and would be used or useful in the near future. An evaluation of his performance when using the counting system in a nonfunctional, practice environment, such as counting a predetermined number of beads or pegs and placing them in a box, showed a decreased accuracy after a successful performance on the first trial. In four subsequent trials, he missed one calculator entry. The student had a history of incorporating maladaptive coping strategies (e.g., leaving the task area; saying, “I don’t need this”; pushing work away) when engaged in academic tasks. Further evaluation was terminated to avoid incorporating maladaptive strategies into his vocational task of counting fruit. Counting practice in the classroom revealed only 20% accuracy, showing minimal improvement compared with his initial performance.

The student’s counting skills without the use of the final step of the compensatory counting system were reevaluated. He was presented with numbers written in the form of multiples of five for a penny-counting task. For the number 45, the student said, “25,” and began counting each penny as five (5, 10, 15, 20, 25). He recognized his error and began to make several groupings of five pennies. He then combined all the pennies and began counting them by one-to-one correspondence. His final count was 25. He committed the same verbal reading error with the number 30, stating 23 and correctly counting out 23 pennies. On another occasion, he maintained a correct verbal reading for 55 but became confused after counting up to 35; he then added two pennies and said, “I’m done.” For the number 44, the student not only misread the number as 34, but also made correspondence errors resulting in a sum of 31.

Discussion

This compensatory system enabled the student to count objects up to 100 without mastering basic number skills, that is, to rote count to 20, recognize the numerals 0 to 9, and count out up to 20 objects (McConkey & McEvoy, 1986). He progressed from minimal success to 100% accuracy in counting in his vocational task of counting fruit. The system also enabled the student to count a subset of objects from a larger set, which is one of the most complex levels of counting (Spradlin et al., 1974).

Because this system was compensatory, it was not intended to teach the student the actual skill of counting; its success was derived from skills other than math, such as motor sequencing skills. The counting system does not require number recognition past five. Number recognition continues to be difficult for him; for example, he continues to be inaccurate when reading most two-digit numbers.

The student’s consistent accuracy in rote counting up to 20 is encouraging and can be attributed to the system particularly because he was not instructed in this area during the 10 week training period. The student also exhibited an awareness that the decades (10, 20, 30, etc.) are sequential. Even after a 10-week summer vacation during which the student received no additional training in counting, he was able to count up to 30 objects with the system.

The increased exposure to counting tasks and basic math concepts provided during the training has been
helpful. The student has been able to generalize the use of the system to different environments and to count different objects. McEvoy (1989) suggested that children's understanding of numbers evolves as a direct result of successful counting experience. This generalization of skill tends to support the contention that children begin to develop math concepts naturally when environmentaly challenged and when the training is meaningful and interesting to them (Baroody, 1986b; McConkey & McEvoy, 1986; Resnick, 1989). The rote counting gains this student exhibited through the use of a compensatory tool also validate the basic occupational therapy assumption that doing is becoming (Fidler & Fidler, 1978).

This compensatory counting system can be modified to suit an individual student's learning style and ability. Many students with mental retardation will need only basic computational skills in their life. This case report provides evidence that such students can benefit from compensatory methods.

Conclusion

Counting is a skill that we use so often in our daily lives that it is difficult to identify how critical it is to our concept of competence. It is, however, one of the areas that quickly separates persons with mental retardation from their peers without mental retardation, especially when they act as if they understand numbers. If you ask a casual friend how many brothers and sisters he or she has, it would be unusual to get 26 as a reply. Similarly, if you ask what time your friend needs to get home, you do not expect to be told 16 o'clock. Further, if you ask for two packets of sugar, you do not expect to receive a handful. In attempting to include persons with mental retardation in the community, it is important to provide them with as many skilled competencies as possible, especially skills that most adults assume their peers share, such as the skill of counting.

Counting also is a skill that is often difficult for children with mental retardation to master. This article described an occupational therapy intervention that uses a compensatory system for counting. This system does not require the student to master basic number skills such as one-to-one correspondence past 10, verbal number recognition past 5, or accurate naming of two-digit numbers. It primarily uses number matching and motor sequencing skills. The system can help a student count up to 100 objects as exemplified in the case report.

This counting system relies on object-oriented external strategies (i.e., picking up and placing). Studies indicate that when comparing preschool children and toddlers with and without mental retardation, both groups rely on object-oriented external strategies to assist memory, and both groups use the same strategies. Differences occur between the two groups as they grow older. Eleven-year-old children with mental retardation tend to continue to use the same strategies, whereas their peers without mental retardation have developed internal memory strategies. In comparing external memory strategies and verbal tasks, 11-year-old students with mental retardation and 7-year-old students without mental retardation were found to use more object-oriented external strategies than 11-year-old students without mental retardation (Bray, Saarnio, Borges, & Hawk, 1994; Fletcher & Bray, 1995).

Object-oriented external strategies are a natural sensorimotor developmental stage that enhances memory, which suggests that incorporating the movement of objects into an academic memory task is a viable compensatory strategy in the school environment. Students with mental retardation are a vital concern in the school setting for occupational therapists, teachers, students, and families. ▲

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