Number Comparison Skills of Children With Moderate Intellectual Disabilities

Laaya Bashash & Lynne Outhred
Macquarie University

In this study the authors investigated the ability of children with moderate intellectual disabilities to compare relative numbers and the strategies they used. Ten children, aged 12 to 18 years, with moderate intellectual disabilities were given a sequence of tasks to assess next number determination; understanding of the n+1>n rule; and number comparison skills. The results showed that nine of the children were able to correctly determine the next number in a sequence and had a good understanding of the n+1>n rule tasks, while six of them were successful on the comparison tasks.

Several studies have made significant contributions to the knowledge of how children acquire number understandings (Baroody, 1993, 1992; Becker, 1993; Fuson, 1988, 1992; Gelman, 1993; Gelman & Meck 1992; Michie, 1985; Steffe, 1992; Sophian, 1992, 1995, Sophian, Wood, & Vong, 1995; Wright, 1991; Wynn, 1990, 1992). The results of these studies have provided information to teachers and parents concerning the assessment and teaching of basic number skills and concepts to children. However, the study of how children with intellectual disabilities acquire number skills has been relatively neglected. Baroody and Snyder (1983) and Porter (1993) believe that this neglect is due to the belief that these children are not able to develop numeracy skills, based on reports of their limited capability to acquire basic number skills (Cronwall, 1974; Gelman, 1982; Brown & Deloache, 1978). In this connection, Gelman and Cohen (1988) found that there are qualitative differences between the ways that children with Down Syndrome solve counting tasks, compared with children of normal intelligence. Carr (1995) reported that two thirds of young people with Down Syndrome were only able to recognise numbers and count. However, Baroody (1986, 1988) indicated that these children are capable of acquiring rule-based counting skills, and benefit from a cognitive approach to instruction. His suggestion would be supported by Caycho, Gunn, and Siegal (1991) who reported no significant differences between the counting behaviour of Down syndrome children and normal children of similar mental age.

Baroody and Snyder (1983) found that very few children with moderate mental disabilities were able to make number-neighbour comparisons. As the ability to compare the relative size of numbers is a fundamental number concept, Baroody (1988) suggested rule-based training of number comparison might be effective in promoting retention and transfer of these skills for children with intellectual disabilities. An aspect of relative size is the knowledge that n+1>n, and this has been emphasised by Test, Howell, Burkhart, & Beroth (1993) who used a strategy based on a "one-more-than" technique in teaching money skills to children with intellectual disabilities.

In this study the abilities of children with moderate intellectual disabilities to count number sets and to compare relative number size were assessed and the strategies children used were observed. The extent to which they understood the n+1>n rule and had 'n after' skills were also investigated. This paper presents the preliminary results for ten children; the final sample will comprise thirty children with moderate intellectual disabilities.

Method

Subjects

The sample comprised ten children with moderate intellectual disabilities (seven Down syndrome) aged 12 to 18 years (Mean = 15) from a special school in a northern suburb of Sydney. The study was approved by Macquarie University's "Ethics Review Committee for Human Subjects". The participation and assistance of the School Principal was requested by discussing the importance of the study and written permission letters were obtained from the parents of all children who participated in the study. Intelligence test scores were obtained from school records and the mean intelligence score for the sample measured with the Stanford-Binet test was 40.2 with a range of 36 to 51.

Description of the tasks

Control Tasks: In order to control the effect of linguistic bias (Siegel, 1982) three control tasks were used. In the first task, children's knowledge of the colours used in the comparison tasks was assessed by asking "Show me the blue (or red) dots." (Dots of different colours were glued on separate cards.) The second task was given to ensure that children understood the concepts of "more" and "same". Children were required to select the set with more dots from two sets which were equivalent in length but contained different numbers of dots (Siegel, 1982). In the third task children's understanding of "point to" or "show me" was assessed by asking them to show (or point) to different objects.

Cardinality Task: The "What's-on-this-card?" task of Gelman (1993) was used to evaluate the understanding of cardinality principle. In this task, the experimenter showed the child a card with a picture of one star on it, and asked "What's on this card?" After a response was given ("a star" or "one star") the experimenter responded "That's right, one star." Next a card with two stars was shown and the child was asked "What's on this card?" Additional trials with more items (up to 10 stars) were given.

N+1>N Rule Task: Children's understanding of the n+1>n rule was assessed by showing the child two sets with equal numbers of chips (two, four, six, and eight) in each. After the child had affirmed that the two sets were equal, the experimenter hid each set with a tissue, then added a chip to one of the sets and asked the child, " Which one has more?" The child was required to respond without counting. In each trial the position of the set with more chips was alternated.

N After Task: A modified version of the "n after task" of Baroody and Snyder (1983) was used to examine the skill of next number determination. In the written form of the task the child was given the written sequence to complete (eg., 1,2,3,4,____, or 4,5,6,7,____). However, in order to equate the written and oral conditions, for the oral task, the experimenter asked "What number comes after?" and then gave a sequence of numbers, rather than simply giving a number and asking for the next number, as Baroody and Snyder had done.

Comparison Task: The "Judging Cardinal Equivalence Task" used by Fuson (1988) was modified in this study. Two long, narrow white cardboard strips of equal length, were glued parallel to each other on a 35◊15 cm green cardboard rectangle. One white strip contained a row of red dots, the other a row of blue dots. The strips were placed in front of the child. Five different comparison situations were administered in this task: equal numbers in one to one correspondence; equal numbers of the same length but not in one to one correspondence; equal numbers with one row shorter than the other; each row the same length with one more dot in one row; an additional dot in one row with the "more" row shorter. The number pairs given were: two, two; two, three; three, three; three, four; four, four; four, five; five, five; and five, six.

Because the language of children with moderate intellectual disabilities is limited (Miller, 1988; Bray & Woolnough 1988), the experimenter modified Fuson's instructions. The comparison question was asked as two separate questions. The child was first asked "Do they (the rows) have the same number of dots, or a different number of dots?" If the answer was 'different" the child was asked "Which one has more?" In order to avoid the bias toward responding with the last choice given (Goldstain, 1969, cited in Fuson 1988), the correct answer to the first question ("same" or "different") was always in the initial position. The children were presented with the number comparisons until they gave incorrect responses for three successive trials. The experimenter then returned to the first failed item and gave a verbal prompt, ("You can count them") or if necessary, the experimenter helped the children to count each row and reminded them of the number in each counted set, before asking the next comparison question. The effect of the hint was recorded.

Results

Control tasks

The performance of children in the control tasks showed that all of them knew the colours and the term "point to" while eight children understood the concept of "more", and nine, the concept of "same" and "different".

Cardinality task

Almost all children applied Gelman & Gallistel's (1978) counting principles on the "What's-on-this-card?" task. All children successfully applied the cardinal counting principle and nine of them, the one-one, and stable order principles.

N+1>N Task

In the n+1>n rule, the subjects showed understanding (nine of the ten were correct) for both small and large numbers. While these children did not count the sets five of them mentioned the number in their response, for example; "This one has more, it is five,"

N-After Task

Results of the n-after task indicated there was no difference between the written and oral situations, with children achieving high scores in both (all children were correct in the written situation and nine in the oral situation).

Comparison Task

The strategies used for the comparison task are illustrated in Figure 1. The most common successful strategy, used in 36% of the 180 responses, was to count each set. However, many responses (21%) involved a matching and counting by finger strategy. In this strategy children first matched one set on the fingers of one hand, the other set on the fingers of the other hand, then counted the fingers on each hand to compare the numbers. Matching the elements of the two sets by putting them in one to one correspondence was another successful strategy (15% of the responses). Sixteen percent of the strategies were perceptual, based on either length or density. Matching and counting the number of elements in each set was relatively infrequent (4%), and for some responses no identifiable strategy was evident (8%). The strategies used for the comparison task are illustrated in Figure 1.

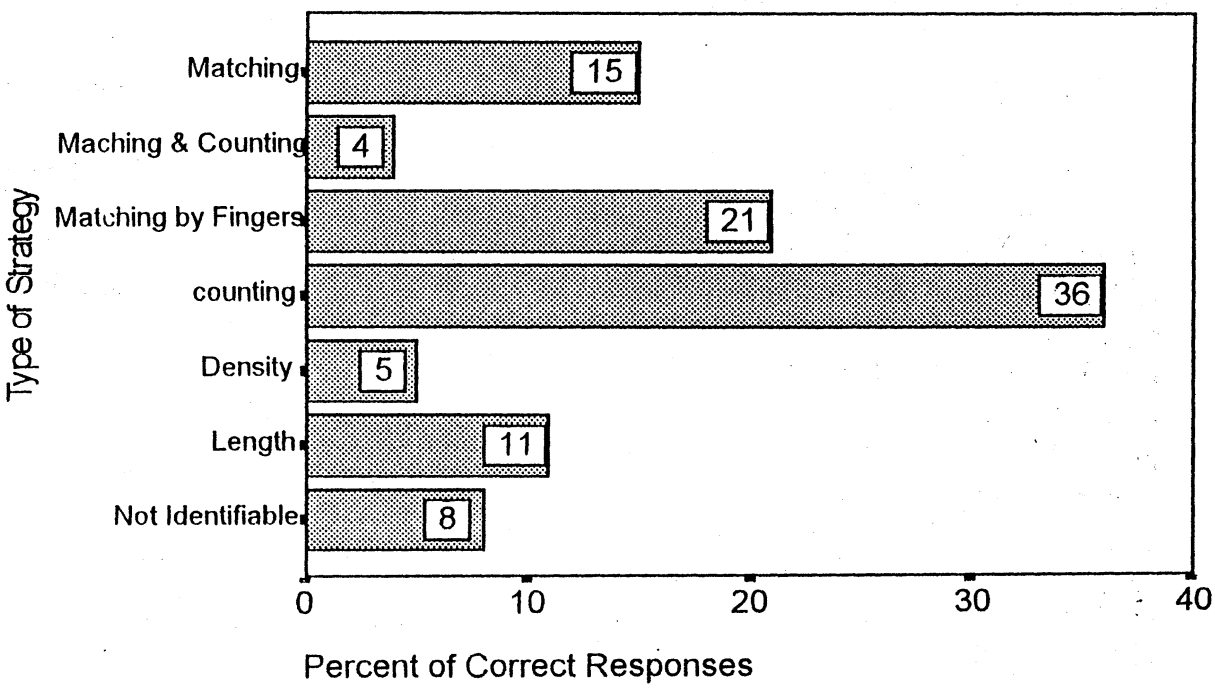

Figure 1: Strategies used on the comparison task.

Of a total of 180 comparison trials, 62% of the responses were correct (45% without a hint and 17% with a hint) and 38% were incorrect. Overall, performance was better for comparisons involving small, rather than large, numbers. Children also gave more correct responses in the trials involving equal numbers in one to one correspondence (seven children were correct) than in trials with the other comparison situations. Table 1 shows that counting was the main strategy used by successful subjects.

Table 1. The performance of the subjects on the comparison task

Subject	Correct response (without hint)	Correct response (with hint)	Not answered or incorrect response	Main strategy
1	18	-	-	counting by fingers
2	16	2	-	counting
3	15	3	-	counting
4	14	4	-	counting & perceptual
5	9	9	-	perceptual
6	10	6	2	counting by fingers
7	-	5	13	not identified
8	1	1	16	matching & perceptual
9	2	-	16	matching
10	0	0	18	

The results presented in Table 1 show that one subject correctly answered all the comparison questions with no hints while one subject had no concept of number comparison. Six of the ten children obtained high scores on the comparison task. The findings showed that giving a hint and then continuing the comparison tasks was most effective for the successful subjects .

Discussion

For children without intellectual disabilities the cardinality principle is acquired before comparison rules (Gelman and Gallistel, 1978). Moreover, Gelman (1993) found that the "What's-on-this-card" task elicited clearer evidence that young children can use verbal counting principles than the other tasks in her study. The results of the present study showed that for these children with moderate intellectual disabilities the cardinality principle was acquired before comparison and that they applied the one-one, stable order, and cardinal count principles in the "what's-on-this-card" task. The findings were also consistent with the results of studies by Baroody (1986) and Caycho et al. (1991) which reported that children with moderate intellectual disabilities have understanding of one-one, stable order, and cardinality principles.

Baroody and Snyder (1983) reported that their subjects were far more successful in determining the next number in a written situation (73%) than in the oral situation (13%). On the contrary, the results of present study showed no difference between the performance of subjects in determining the next number in written and oral situations as nine of the ten children were successful in both. A reason for the differing results might be the different methods of assessing 'n after' skills in the oral situation in the two studies (as mentioned previously).

The results of a study (Baroody and Snyder, 1983) indicated that children with moderate intellectual disabilities had low understanding of the $n+1>n$ rule. Twenty percent of the children in their sample gave correct responses for small numbers and 13% for large numbers. In contrast to their findings, the results of the present study showed that nine subjects understood the $n+1>n$ rule for both small and large numbers. The investigators believe that the difference between the results of these two studies might be a consequence of the way in which children's knowledge of the $n+1>n$ rule was assessed. In this study subjects were not required to count the two sets in order to find out which set had one more. They had to understand the rule that if a single item was added to one of the two equal sets, that set would have more items regardless of the size of the set. Another possible explanation of the high performance of subjects in both the 'n after' and $n+1>n$ tasks might be an increasing emphasis in recent years on teaching mathematics to children with intellectual disabilities (Porter, 1993).

Young and McPherson (1976) found that all of their subjects (children of 4 to 7 years of age with normal intelligence) were able to make correct judgments of relative numerosity when the sets were in one to one correspondence. In the present study seven of the subjects were able to compare relative number judgment in one to one correspondence. A reason for this might be the low intellectual abilities of the subjects. These results are also consistent with Michie's (1984) findings that children made significantly fewer errors when misleading perceptual cues were omitted, or they were assisted to remember before making comparison judgments. Fuson's (1988) claim that when children are reminded of the number of elements in each set counted before the relational questions are asked, children give more correct responses to equivalence tasks was also supported.

Baroody (1986) found that children with moderate intellectual disabilities were more successful in making cardinal sets with their fingers than with other objects and suggested that a reason for this is that children only gradually extend their knowledge of number to objects outside themselves. In the present study use of the strategy in which children used their fingers to match and to count each set in the comparison task was successful for numbers up to five. However, for numbers greater than five this strategy was not successful.

Summary

The results of present study indicated that the children were capable of developing rule-based number skills, such as the n+1>n rule, and of using counting strategies as a means of comparing two sets of numbers. It was also evident that the form of the tasks used to assess number knowledge was crucial for children with moderate intellectual disabilities. Therefore, with well designed teaching strategies children with moderate intellectual disabilities should benefit from an emphasis on cognitive techniques of instruction rather than on rote learning. Such teaching strategies might emphasise the acquisition of number rules to facilitate computational shortcuts (Baroody, 1995).

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