DO CHILDREN WITH DOWN SYNDROME HAVE DIFFICULTY IN COUNTING AND WHY?

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A systematic review of literature in the area of counting in Down syndrome was conducted to identify and analyze ability to count of children with Down syndrome. We firstly reviewed the most famous theories which have explained how typically developing children acquire counting, and then we discussed how children with Down syndrome acquire counting according to these theories. We showed how children with Down syndrome have a deficit in counting and demonstrated the main reasons which may lie beneath this difficulty. Inspite of this difficulty in counting, we found that children with Down syndrome benefited from intervention. We ended the review by briefly summarizing the characteristics of good interventions to demonstrate how we can improve children with Down syndrome's ability to count.

Many studies have been conducted in different areas of Down syndrome. Language has a big part in these studies but there are few studies about numerical ability, especially counting. Existing research suggests that children with Down syndrome have low attainment regarding numbers compared with their ability in reading (e.g. Nye, et al. 1997, 2001). Because we use numbers in most of our life activities for example, telephone numbers, home numbers, bus numbers, etc, any difficulties with numbers may affect our daily activities. Furthermore, counting underpins higher levels of numerical ability. A variety of studies (e.g. Carpenter, et al.1981; Starkey and Gelman, 1982; Baroody, 1987; Wynn, 1992; Baroody, 1996; Porter, 1999 a, 1999 b; Nye et al.2001; Bashash, et al. 2003, Butterworth, 2005) have shown that counting can support the development of other arithmetical activities. Young children can solve word problems or simple addition sentences by using a concrete counting strategy, also accurate object-counting experience is necessary for the development of some advanced skills (Baroody, 1986 a, b; 1987). In the following section, we will look in depth at what we know about counting in Down syndrome.

Procedures first versus *Principles first* are the two major accounts which have attempted to explain how children acquire counting. An assumption of the *Procedures first* theory is that the learner is able to copy other people and reinforcement plays an important role in emphasizing the experience which the child has learnt. According to this theory, children acquire counting by learning from others or repeating the number words which they have learnt from adults. They have no innate understanding about numbers but, depending on the feedback that they receive, and if enough of the counting procedures have bean learned, the child can generalise and apply it to a novel task. According to this account children acquire counting procedures first before having an understanding of counting (e.g. Fuson and Hall 1983; Briars and Siegler, 1984; Fuson, 1988).

The second approach is the *Principles first*. Gelman and her colleagues assume that young children have an innate understanding of counting and that the very young child has an implicit understanding of number. She suggests that there is a set of five counting principles which define correct counting and young children have a primary concept of numbers consisting of these principles. Three of these principles are the one-to-one, the stable-order and the cardinality. The one-to-one principle means that each item to be counted must have a unique tag and every item in the array has only one tag. The stable-order principle requires that the number tags must have a permanent order across counts. The cardinality principle means that the last number tag represents the total number of a set. The previous principles constitute the how-to-count principles. The remaining two principles are the order-irrelevance principle and the abstraction principle. The order-irrelevance principle means that objects can be processed in any order. The abstraction principle means that any sets of objects, a real or imagined, can be counted. According to this theory, if children do know the counting principles they should detect counting errors. Furthermore, they should recognise that it is acceptable to start counting from the middle of the row or to count alternate items of the same kind and then back up to count the remaining items of another kind in a given display (e.g. Gelman and Gallistel 1978; Gelman 1982; Gelman and Cohen, 1988).

Do children with Down syndrome acquire numbers by rote?
Some studies have suggested that in contrast to typically developing children, children with Down syndrome learn to count by rote. Gelman and Cohen (1988) suggest that Down syndrome children learn to count by the associative learning model. When they face a new task they cannot benefit from hints even if these hints consist of explicit instructions or presentation of possible solutions to solve this novel task. By contrast, the typically developing children in their study were able to generate novel solutions and to self-correct their mistakes. They benefited from subtle hints to solve a novel task they also varied their solutions according to different instructions. Their learning to count seems to be controlled by a principle model of learning. Cornwell (1974) supports Gelman and Cohen's view that children with Down syndrome acquire counting by rote. He added that learning counting by rote does not enable them to acquire high levels of arithmetic concepts.

These findings support Hanrahan and Newman's (1996) view that children with Down syndrome can learn skills of rote counting and number recognition up to number ten. They suggest that when children with Down syndrome reach five years old, they can learn more about the rote learning of arithmetic skills and can learn the basic rules of counting. Another view, taken from Fuson's (1988) work with preschool children, supports this argument, that young children acquire different meaning of numbers in different contexts. They learn to count by rote and they recite a number sequences with no real meaning and children under three and half years of age were capable of counting up to number ten correctly without knowing that the last number word equals the whole number of a set.

A question has been raised from the previous argument *How do we know that the children acquire counting by rote?* in other words, *What are the signs of rote learning?* Children's responses on basic counting and error detection tasks might answer this question. Children who acquire counting by rote produce different types of errors. Fuson, et al. (1988) suggested that in typically developing children, there are three common types of errors which are frequently made. They are object skipped, multiple words-one point, point-no word errors. Children with Down syndrome made all of these types of errors, Porter (1999, a) revealed that children with Down syndrome who made one-one errors were more likely to miss numbers during their counting than to multiple count and most of their mistakes were point-no word and skipped-object errors. Gelman (1982) argues that retarded children produce types of errors which are not made by typically developing children. Typically developing children make skipped-objects and double count errors during their counting. In contrast, retarded children make the previous types of errors plus recount, multiple words-one point and point-no word errors.

Further signs of rote learning are that children will not be able to detect or recognise counting errors or even will not able to produce the last tag response as an indicator of knowing cardinality. Moreover, they cannot self-correct their counting errors or they sometimes give inconsistent answers regarding their counting of a number string such as saying a letter or a word instead of number words. They sometimes give one object more than one tag (Gelman, 1982). Furthermore, if the children are interrupted they will not be able to complete counting they may have to start again or stop counting. Cornwell (1974) noticed that if children with Down syndrome were interrupted during their counting they could not complete counting or start again correctly because they had learnt to count by rote.

Do children with Down syndrome acquire numbers by principles?
Counting principles' theory is another account of how young children acquire numbers. At least some children with Down syndrome are able to learn counting principles. Caycho, et al. (1991) revealed that most children with Down syndrome appeared to show an implicit understanding of the one-to-one and stable order principles. The children found it easier to recognise correct counting than to detect an error. Furthermore, a few children succeeded in several trials of the modified counting task (the examiner asked the child to count with the second or third item being the numbers one to number five) and they were able to deal with varied objects as things to be counted. Moreover, there were no differences between the counting behaviour of the children with Down syndrome and the preschool children of similar developmental age.

Further evidence supports the previous claim emerging from Porter's (1999 a) work with pupils with Down syndrome. She looked in depth at the performance of the children with Down syndrome and their understanding of counting. Children were presented with a basic counting and an error detection task. She found that some children were able to detect errors which were made by a puppet. Moreover children with Down syndrome showed some understanding of cardinality. She suggests that children with Down syndrome with severe learning difficulties demonstrated some understanding of the count task but they still have particular difficulty with learning the number string.

A longitudinal study was conducted by Nye et al. (2001) on children with Down syndrome also found that children demonstrated some underlying understanding of cardinality. They compared the performance of two groups of children (Down syndrome and typically developing children) on number tasks. They examined children's understanding of cardinality by asking the child to give a specific number of objects. Only a third of their sample was able to give a specific number of objects. They concluded that some children with Down syndrome demonstrated some understanding of cardinality like typically developing children. The profile of the children with Down syndrome in their sample confirms that these children have some understanding of cardinality and their finding do not support the view that children with Down syndrome have no conceptual understanding of number.

Bashash et al (2003) supported the view that children with intellectual disability including children with Down syndrome have an underlying understanding of counting. Thirty students with intellectual disabilities (13 Down syndrome) aged between 7 and 18 years were examined on different counting tasks such as rote counting, object counting, and novel counting tasks. They found that the entire sample in their study demonstrated an underlying understanding of number. Their findings showed that all the children applied the first three principle of Gelman's theory (one-to-one, stable-order and cardinality principles) in counting a row of objects. All middle and older age children knew that the number of objects in a set remained the same even if the objects were rearranged. An important finding of this study is regarding the explicit understanding of numbers. Bashash et al. found that 60% of their sample was successful on the order-irrelevance task and this shows an explicit understanding of numbers according to the "principles first" theory.

An important question is raised here, *How do we know that children acquire counting by principles?* Gelman (1982) has the answer to this question in her study. She reported that the children acquire counting by principles if they can correct their own counting errors. They should give every object one tag and one tag only (one-to-one principle), when they are asked to count a set of objects several times they produce the same responses (stable-order principle) and when they are asked to answer the *how many?* question they give the last tag response (cardinality principle). Further evidence is that they can detect counting errors, they recognise that it is acceptable to start counting from the middle or to count some kind of object and complete the counting with another type of object. Furthermore, Nye et al. (2001) examined children's ability to understand cardinality by asking the child to give x number of objects so if the child has an understanding of cardinality he/she will be able to give the correct set of objects.

In light of the previous research, one argument is that very young children with Down syndrome acquire numbers in different contexts by rote like typically developing children, but they are able to learn and acquire numbers by principles afterwards. Learning counting without underlying understanding does not support the development of other strategies to solve a novel problem. Furthermore, children do make different types of errors which increase according to the difficulty level of the counting task because of the lack of understanding or of having difficulty in learning the procedures.

However, we cannot accept that all children with Down syndrome do not have an implicit knowledge of principles which guide their acquisition of counting. Gelman and Cohen (1988) suggest that children with Down syndrome could not utilise hints or any demonstrations of the possible solutions to solve a novel problem. And they concluded that this group of children has a deficit in counting and they have learnt to count by the associative learning model. Although the majority of the children with Down syndrome in their sample experienced some difficulty in counting, there were two children with Down syndrome who were excellent counters. These two children were able to do self-correction for their false starts. They benefited from subtle hints as well as inventing new solutions to solve the task. Hence they demonstrated some underlying understanding of counting principles. However, Gelman and Cohen did not consider these two children in drawing their conclusion about children with Down syndrome's ability to count. Furthermore, it is not enough to say that children with Down syndrome acquire counting by rote, evidence suggests that some children demonstrated some understanding of counting (e.g. Caycho, et al. 1991; Porter, 1999 a, 1999 b; Nye et al. 2001).

On the other hand, the study of Bashash et al. (2003), which demonstrated that children with Down syndrome have an explicit understanding of counting, is still far from the truth. Children in their sample received training programmes on the same tasks which they had examined for ten years. We do not know about the children's profile before this training, nor about their profile of acquisition, simply about their gains after ten years' intensive training. Although the findings of the previous studies emerged from quite a small sample and they varied in their methodology, most of their findings support that we still need further research in the area of counting especially in Down syndrome. We still do not know too much about this group of children's ability to count.

Individual differences

Studies show variations within samples. Some children with Down syndrome perform well on a counting task and some not. Gender, mental age and chronological age are possible variables which affect children's ability to count and this may explain this variation. It has been argued that there is a relationship between counting and mental age, chronological age and gender. Cornwell (1974) revealed that people with Down syndrome have difficulties in dealing with numerical symbols with or without expressive language. Their impairment improved somewhat with age and there are some facilitative effects of using familiar objects at the higher mental age level. Cornwell's findings revealed that there was significant improvement in some numerical concepts such as identification and designation of numerical units with mental and chronological age.

Furthermore, Sloper, et al. (1990) suggest that there is a relationship between age and academic attainments, as the children gained in ability over time. It may however also be related to the age at which schools introduced the children to reading, to writing and to do number work, with some of the younger children with Down syndrome having very little experience in these areas. The finding of Cornwell and Sloper, et al. concurred with Shepperdson's findings (1994) that some participants with Down syndrome were able to master simple skills of numbers but some of them had very poor number skills. By contrast, Shepperdson found some teenagers with Down syndrome who had reasonable number scores at teenage but declined in adulthood and some of them who had poor number scores did not improve and even lost some number skills. In addition, Nye, et al. (1995) found that the children with Down syndrome may not demonstrate a steady progression of numerical skills with chronological age. One explanation for contrasting research findings concerning the importance of age is that of individual differences coupled with the size of the sample.

Do some children with Down syndrome have a deficit in counting and why?

The majority of the relevant literature has shown that there is a deficit in counting in children with Down syndrome (e.g. Cornwell, 1974; Casey et al.1988; Shepperdson, 1994; Hanrahan and Newman, 1996; Porter, 1999 a, 1999 b; Nye et al.2001). It has been argued that there is a variation in performance in skills and understanding of the counting in individuals with Down syndrome (e.g. Porter 1999 b). Baroody, (1986 a, b) suggests that there are deficiencies in basic counting competencies and systematic oral-and–object counting errors in children with mild and moderate learning difficulties including Down syndrome children. Basic counting knowledge, which is acquired by most typically developing children before formal schooling, cannot be taken for granted in children with learning difficulties of school age. Error analysis provides indications of oral and object-count difficulties and a guide for remedial efforts.

Children with Down syndrome can count a small set of objects as well as produce short count sequences. In a recent study conducted by Nye et al. (2001) on both typically developing children and Down syndrome children, they compared the two groups of children on procedural counting ability. They found that children with Down syndrome performed less well than typically developing children on the counting tasks. Children with Down syndrome produced shorter number sequences than typically developing children. They counted a smaller set of objects than typically developing children.

Gelman and Cohen's (1988) work on typically developing children and Down syndrome children supports the view that children with Down syndrome experience difficulties in counting compared with typically developing children. They found that children with Down syndrome were not able to solve a novel number task, they could not benefit from either implicit instructions or explicit ones. When they were presented with the novel task they were not able to develop new strategies to solve it. Contrary to the Down syndrome profile, typically developing children performed well on the novel task. They were able to solve the task as well as to develop new strategies and self-correct their mistakes.

Children with Down syndrome produce different types of errors during their counting. They make skipped-object, double count, point-no word errors. Porter (1999, a) found that children with Down syndrome made skipped-object errors more than multiple words-one point errors. However, most of their mistakes in her sample were point-no word and skipped-object errors. Thorley and Woods (1979) reported from their daily observations of eight children with Down syndrome during training programmes that children have a tendency to jump ahead, miss counting individual objects or be unsuccessful in remembering which objects they have counted.

There are varied explanations for the difficulties which children with Down syndrome have in counting. Young children with Down syndrome may sometimes put much effort into avoiding learning and taking part in avoidance strategies and can therefore be putting themselves unnecessarily at further cognitive disadvantage. Wishart's work with children with Down syndrome concerns learning styles in children with Down syndrome. She referred to avoidance strategies as an understandable response from a very early age when children with Down syndrome are involved in new learning situations where they experience high levels of failure. In her study (2001), she explored how children respond to a new learning task and what strategies they use. She found that children preferred to avoid the hard tasks by refusing to work or by doing some bits and leaving the remaining task or by doing some tricks to stop work.

Furthermore, Germain (2002) conducted a small case study on a child with Down syndrome (Paul). When Paul was presented with a hard counting task (the concept of before and after) some inappropriate behaviour appeared. His teacher arranged the cubes on the table to show and help him to grasp the concept of after and before but he found it a very hard task so he held the cubes and gave them back to his teacher. Germain explained this behaviour as Paul might be adopting counterproductive behaviour strategy when faced with a hard task requiring advanced cognitive skills. To summarise, it appears that children with Down syndrome show lowered motivation to perform the task, especially if this task is new or hard. They prefer to withdraw from the whole situation rather than to try and fail or pass.

Further explanation of these difficulties is that they may also be influenced by the low expectations that adults have regarding their ability to learn. For example, in Egypt, teachers still have a low expectation regarding these children's ability to learn especially academic subjects. They think that the most appropriate thing is to teach these children a manual occupation such as carving, and sawing etc., rather than teaching them to have a qualification. They cannot believe that these children are able to learn and achieve academic subjects like typically developing children. Although, a lot of effort has been made by the Egyptian government to change these views by sending professionals abroad to see and learn from other countries' experiences regarding children with learning difficulties, it will take time to change.

Another explanation for these difficulties lies with short-term memory. Research with children with Down syndrome reveals a deficit in their auditory short-term memory. Down syndrome people have problems of hearing and articulation which lead to a reduction in verbal short-term memory span. Due to the impairment in verbal short-term memory, children found difficulty in acquiring new vocabulary words such as number words. Furthermore, to learn a string of numbers, it is necessary to repeat and rehearse these numbers and children with Down syndrome have a difficulty in using rehearsal strategy (Hulme and MacKenzie 1992; Jarrold, et al. 1999; Purser and Jarrold, 2005). An important questions has been raised here *Is there is a relationship between maths and short – term memory?*

As mentioned before, research suggests that children with Down syndrome have short-term memory difficulties compared with other children with and without learning difficulties. They suffer from several problems such as deficit in their phonological loop, poor articulation and deficit in rehearsal strategy. One or all of those difficulties may contribute to their difficulties in counting. Gathercole and Pickering (2001) suggest that the children with poor phonological loop function may have a difficulty in acquiring new words such as number words. Furthermore, children need to be taught to rehearse the number sequence in learning new words especially those with similar sounds which confuse children and are harder to learn. Phonological similarity affects children's ability to recall words. Children found it more difficult to repeat similar sounding words than dissimilar ones and this can apply also to number words.

Some studies have been concerned with the relationship between working memory and maths. A recent piece of research conducted by Keeler and Swanson (2001), investigated working memory and mathematical disabilities. Fifty-four children with mathematical disabilities were tested on digit sentence span task and mapping and directions task. The purpose of digit sentence span task was to assess the children's ability to remember numerical information. The purpose of the second task is to determine whether the children can remember a sequence of directions on a map. The findings of this study showed that children with mathematical disabilities showed poor working memory and children who have working memory problems have poor performance in mathematics. They mentioned that to improve maths achievement in children with mathematical disabilities we have to understand the working memory deficit and to try to develop and improve it.

Wilson and Swanson's (2001) study was concerned with the relationship between working memory and mathematics ability across a broad age span. Two groups of men and women with and without mathematical disabilities were tested on working memory tasks (verbal working memory and visuo-spatial working memory). It was found that the individuals without mathematical disabilities performed better than the group with mathematical disabilities on both verbal and visuo-spatial working memory. Further the performance of the individuals on verbal and visuo-spatial tasks predict their performance on mathematics. They stress that working memory plays a critical role in mathematics and the central executive system plays an important role in predicting maths performance.

Research conducted by Furst and Hitch (2000) lends some support to the previous view. Thirty university students were tested on two experiments which were concerned with some additions problems. Their findings supported the previous research findings that the multi-digit arithmetic involves executive and phonological systems of working memory. The phonological loop plays an important role in holding and storing the information during calculation. However, it must be noted that there is a lack of studies which are concerned with the relationship between maths, in particular counting and working memory. The previous studies were held on typically developing individuals and very little was known about the relationship between working memory and maths in individuals with Down syndrome, of course more research is needed in this area.

Research in language provides a further explanation of why children with Down syndrome have difficulty in counting. The most relevant research indicates that children with Down syndrome have a language deficit (e.g. Buckley, 1993 a & b, 1999 ; Abbeduto, et al. 2003; Roberts, et al. 2005). They produce short sentences as well as having a speech production problem. They experience some articulation difficulties which might affect their ability to learn. Research carried out by Oliver and Buckley (1994) indicated that there is a wide range of individual differences in language acquisition in children with Down syndrome and these children proceed in their language development at a slower rate to a two-word stage than typically developing children.

Finally, one further linked explanation of this difficulty in learning number strings is that spoken instruction rather than visual presentations are used. Bird and Buckley (1994) recommend using visual representation of number sequences to teach children number strings. By contrast, Marcell and Weeks (1988) found that there is no effect for the type of modality on children with Down syndrome's performance on a memory task. They found other children with learning difficulties performed better when information was presented visually than auditorially but children with Down syndrome did not demonstrate any differences when information was presented visually, however, there is a lack of evidence which supports their view. However, using both modes might be important in suppressing any difficulties which children find in a task. Again, children with Down syndrome's difficulty in acquiring number strings may be due to deficit in their expressive language, deficit in their auditory short-term memory, and difficulty in using rehearsal strategy and the limitation in their short-term memory span.

Effects of intervention

Environment affects children learning especially counting. Some intervention studies have been conducted to explore the effect of the environment on learning academic subjects such as counting. Children with Down syndrome can benefit from intervention to improve their numerical ability especially counting. Thorley and Woods (1979) have conducted a training programme for eight children with Down syndrome aged between 3.5 years to 5.2 years. They aimed to teach the preschool children with Down syndrome preschool minimal objectives such as rote count to 5, match numerals 1-5, order printed numerals 1-5, etc. At the end of 54 sessions children achieved the programme objectives plus one child was able to achieve additional number skills such as counts backwards from ten, counts to 39 and place numerals in order. They explained the cause of this improvement that he had more education than his peers as well as he is older than them. Two children of this sample achieved 82% to 61% of the programme objectives and the remaining children made a satisfactory level. Thorley and Woods do believe that with continued improvements in teaching technology and with more frequent practice opportunities, with dividing the task into small steps, children with Down syndrome will be able to learn.

Baroody's work with children with learning difficulties suggests that children with learning difficulties benefit from feedback. Training records indicate that, on several occasions, telling participants that their answer was incorrect apparently had the effect of promoting them to reflect on their strategy and make adjustments. Also, instructional planning should be based on diagnoses of specific individual strengths and weaknesses (Baroody, 1986 a, 1986 b; 1996). Baroody, (1988) designed a training programme to examine if children with mentally retardation are able to learn the magnitude-comparison rule (which means the number comes after another is bigger than the previous one). Trained children demonstrated the ability to learn and maintain the magnitude-comparison rule.

Some studies have used games to teach children with Down syndrome how to count. For example, McConkey and McEvoy, (1986) used dice game to teach children how to count. They chose students with Down syndrome who had at least five years of education before teaching them. They assessed their ability in rote counting, recognising numerals, cardinality and making a set. Most of the students in their study were able to rote count to ten but there were some who could count further. They found difficulty in counting a set of objects, especially large ones, as well as in giving a set of objects. McConkey and McEvoy used dice to play different games with the children (like bus numbers or a car park) to teach children counting and other number skills. They found that children with Down syndrome who played dice games improved and progressed while the control group had not made any progress at the end of the six-week period of training.

Other studies asked parents or adults to give support to the children during learning. For example, Nye, et al. (2001) examined the effect of parental support for counting objects in children with Down syndrome and typically developing children matched for non-verbal mental age. They asked parents to help their children (both of the groups) to succeed on the task. They found that both children with Down syndrome and typically developing children benefited from support and their performance on counting objects was better than on the tasks which were performed without support. During the unsupported task, an assistant encouraged the children to solve the task without giving them any help.

A recent review carried out by Butler et al. (2001) on teaching children with mild and moderate mental retardation maths, reviewed 16 studies over a ten year period that were concerned with mathematics intervention in mild and moderate children with mental retardation. They found that teaching maths has shifted from using basic skill instructions such as using paper and pen or boards in teaching children maths to computation and problem solving instruction. They also found that children benefited from peer tutoring, feedback, explicit instruction as well as practice. They concluded that children with mild and moderate mental retardation learned to use cognitive strategies effectively when the previous elements were included in provision.

Bashash et al. (2003) believed that if students with intellectual disabilities were exposed to numerical training courses they would be able to develop new strategies to solve new numerical tasks. Training programmes should stress teaching counting because of its important role in developing new mathematical strategies. Thirteen children with Down syndrome out of thirty children with intellectual disabilities were included in their study. The chronological age of these children ranged between 7 to 18 years. They were provided with individualised instructions in mathematics such as rote counting, matching and making a set during the class activities. Older children (more than 12 years old) were provided with a money skill programme. These programmes were designed by the teachers who work with the children. Bashash et al. examined children on the number tasks which the children are dealing with daily. Their finding supports the idea that such programmes could improve children's ability to understand numbers in particular counting.

Studies have tried to identify the characteristics of good intervention. Lewis and Norwich (1999) reviewed research in the area of Down syndrome that concerned intervention (e.g. Dunst, 1990; Pitcarin and Wishart, 1995; Gibson, 1996). They found that there is a need for different teaching strategies to meet the developmental differences in children with Down syndrome. These include:

> *Error-free (not trial and error) learning, the use of novelty to counter a tendency to perseverate, teaching single tasks separately, using visual not*

> *aural presentations, providing explicit consolidation of learning, monitoring of off-task behviour.* (p. 44)

Wishart (2001) points to the characteristic of learning style of the children with Down syndrome as:

> *an increasing use of avoidance strategies when faced with learning new skills, a growing reluctance to take the initiative in learning contexts, an over dependence on/misuse of social skills in cognitive contexts. (p. 50)*

She emphasises in most of her studies that children with Down syndrome prefer to withdraw from the task rather than complete the task making errors (Wishart, 1993, 1996 a&b, 2001). Wishart stresses that we should give children with Down syndrome suitable reinforcement and appropriate support without making the child dependent on others. Motivation plays a key role in the learning and development of these children, especially when they acquire new skills.

Bud-Fredericks (1990) recommend that basic adding and subtracting skills can be taught by using a calculator. Calculators are used in money matters, shopping, grocery, and prices of food so children with Down syndrome can use calculators as a tool that assists them to pass their difficulties with numbers. Bird and Buckley (1994) suggest that number sequence patterns can be used to improve counting, both for ordinary counting, and counting by 10's and visual skills can be used to help children with Down syndrome to learn counting and enumeration. For example, number strips, lists, steps and tables may help. In addition, rehearsal strategy can be used to encourage children with Down syndrome to remember number words for rote counting, counting in twos, days of the week or months of the year.

To sum up, although intervention studies vary in their objectives and methodology, they all aimed to improve children's ability in maths. The number of children who were involved, the number of sessions varied between these studies but most used a small number of children and a few sessions. The level of details, which were provided with these studies, was not enough and only a very few studies provided any evidence of maintenance. Despite the previous limitations, their findings are encouraging and we have to go on to see the effect of intervention in children's ability in maths, in particular in counting. We cannot leave children without intervention and expect that they will improve. As mentioned before, there are enormous variations between children with Down syndrome and these variations in their abilities and the difficulties that they have in the expressive language may affect the results of the intervention.

Summary and conclusion

This article has been concerned with counting in Down syndrome. In the first part, we have summarised some of the most important studies, which were concerned with counting, more specifically in Down syndrome. There are two accounts which attempt to explain how children acquire counting. In the *principle first* theory, Gelman and her colleague propose that very young children have innate understanding of number. They assume that there are five principles guiding the child's counting behaviour. The *how to count* principles are one-to-one, stable-order and cardinality, the other two principles are order-irrelevance and abstraction principles. According to their implicit understanding, children will be able to invent new strategies to solve a novel task. They will be able to detect errors as well as self-correcting their mistakes (e.g. Gelman and Gallistel 1978; Gelman 1982; Gelman and Cohen, 1988).

In the *procedures first* theory, Fuson (1988) proposes that children acquire procedures of counting before having an implicit understanding. Children do not have an innate understanding of number, they learn about number from adults by copying others during different contexts. The more children receive reinforcement and practice the more they will be able to generalise and use what they have learnt in a novel context. Practice gives the child the opportunity to count flawlessly and to construct new solutions for the novel task. According to this theory, when the child has acquired the procedures of counting then he/she will be able to abstract the rule and achieve correct performances across tasks.

Regarding how children with Down syndrome acquire counting, Gelman and Cohen (1988) assume that their counting behaviour is guided by associative learning. They have not an implicit understanding of counting. Their evidence emerged from the performance of children with Down syndrome in a novel task. Children could not benefit from implicit as well as explicit instructions. They could not correct their mistakes and showed less ability to invent new solutions to solve the task as typically developing children. A contrasting view was taken by Caycho, et al. (1991); Porter, (1999 a) and Nye, et al. (2001). Some children with Down syndrome in Porter's study demonstrated some understanding of counting. They were able to detect some errors made by a puppet. Even Nye et al. found a third of children with Down syndrome in their sample showed some understanding of cardinality. They measured children's ability to understand cardinality by asking the child to give a specific number of objects. A third of their sample was able to give a small set of objects.

The majority of the relevant literature has shown that there is a deficit in counting in children with Down syndrome (e.g. Casey et al.1988; Shepperdson, 1994; Hanrahan and Newman, 1996; Porter, 1999 a, 1999 b; Nye et al. 2001). They were able to produce short number strings rather than long ones. During a counting task they made several errors that varied among skipped-object, double count, point-no word, and multiple counting errors. However, they were likely to miss number more than to double count (Porter, 1999 a). Some explanations regarding why children with Down syndrome have difficulty in counting were presented. To summarise, children with Down syndrome may experience difficulty in counting because of a deficit in language and memory. Further explanation is related to the environment, children may not have been exposed to a rich counting environment or because of the low expectations which their teachers have regarding the children's ability to learn.

Some studies attempt to improve children with Down syndrome's ability in number. Most of these studies trained a small number of children and all demonstrated that children were able to benefit from intervention. Although many of these studies did not provide evidence of maintenance and their training methods were not clear but their finding is encouraging to conduct further research into improving children's ability generally in number and particularly in counting (e.g. Thorly and Woods 1979; Baroody, 1986 a & b, 1996).

References

Abbeduto, L., Murphy, M., Cawthon, S., Richmond, E., Weissman, M., Karadottir, S., and O'Brien, A. (2003). Receptive language skills of adolescents and young adults with Down syndrome and Fragile x syndrome. *American Journal of Mental Retardation*. Vol. (108), 3, 149-160.

Baroody, A. J. (1986, a). Basic counting principles used by mentally retarded children. *Journal for Research in Mathematics Education*, vol. 17, 5, 382-389.

Baroody, A. J. (1986, b). Counting ability of moderately and mildly handicapped children. *Education and Training of the Mentally Retarded*, 21, 289-300.

Baroody, A. J. (1987). The development of counting strategies for single-digit addition. *Journal for Research in Mathematics Education*, 18, 141-157.

Baroody, A. J. (1988). Number-comparison learning by children classified as mentally handicapped. *American Journal of Mental Deficiency,* 92,461-471.

Baroody, A. J. (1996). Self-invented addition strategies by children with mental retardation. *American Journal on Mental Retardation*, Vol. 101, 1, 72-89.

Bashash, L., Outhred, L. and Bochner, S. (2003). Counting skills and number concepts of students with moderate intellectual disabilities. *International Journal of Disability, Development and Education,* vol. 50, 3, 325-345.

Bird, G. and Buckley, S. (1994). Meeting the Educational needs of children with Down's syndrome. A handbook for teachers. University of Portsmouth.

Briars, D. J. and Siegler, R. S. (1984). A featural analysis of preschooler's counting knowledge. *Developmental Psychology*, 20, 607-618.

Buckley, S. (1993, a). Language development in children with Down's syndrome: Reasons for optimism. *Down's syndrome: Research and Practice*, 1, 3-9.

Buckley, S. (1993, b). Developing the speech and language skills of teenagers with Down's syndrome. . *Down's syndrome: Research and Practice*, 1 (2), 63-71.

Buckley, S. (1999). Improving the speech and language skills of children and teenagers with Down syndrome. *News and Update*: 1(3), 111-128.

Bud-fredericks, H. D. (1990) Education of the child and adolescent. In S.M. Pueschel (Ed.) *A parent's guide to Down's syndrome: Toward a brighter future. Baltimore: Paul.H.Brookes.*

Butler, F., Miller, S., Lee, K. and Pierce, T. (2001). Teaching mathematics to students with mild-to-moderate mental retardation: A review of the literature. *Mental Retardation, vol. 39, 1, 20-31.*

Butterworth, B. (2005). The development of arithmetical abilities. *Journal of Child and Psychatry* 46: 1, pp 3-18.

Carpenter, T. P., Hiebert, J. and Moser, J. M. (1981). Problem structure and first-grade children's initial solution processes for simple addition and subtraction problems. *Journal for Research in Mathematics Education*, 12, 27-39.

Casey, W., Jones, D., Kugler, B. and Watkins, B. (1988). Integration of Down's syndrome children in the primary school: a longitudinal study of cognitive development and academic attainments. *British Journal of Educational Psychology*, 58, 279-286.
Caycho, L., Gunn, P., and Siegal, M. (1991). Counting by children with Down syndrome. *American Journal on mental retardation, 95, (5), 575-583.*
Cornwell, A. C. (1974). Development of language, abstraction, and numerical concept formation in Down's syndrome children. *American Journal of Mental Deficiency*, vol.79, 2, 179-190.
Dunst, C. J. (1990). Sensorimotor development of infants with Down's syndrome. In D. Cicchetti and M. Beeghly (Eds). *Children with Down's syndrome: A developmental perspective.* Cambridge: University press.
Furst, A., and Hitch, G. (2000). Separate roles for executive and phonological components of working memory in mental arithmetic. *Memory and Cognition*, 28 (5), 774-782.
Fuson, K. C. (1988). Children's counting and concepts of number. London: Springer-Verlag.
Fuson, K. C., Briars, D. J. and Secanda, W. G. (1988). Correspondence errors in children's counting. In K. C. Fuson (Ed.) *Children's counting and concepts of number.* London: Springer-Verlag.
Fuson, K. C. and Hall, J. W. (1983). The acquisition of early number word meanings. In H. Ginsburg (Ed.), The development of children's mathematical thinking. New York: Academic Press.
Gathercole, S. and Pickering, S. (2001). Working memory deficits in children with special educational needs. *British Journal of Special Education*, vol. 28, 2, 89-96.
Gelman, R. (1982). Basic numerical abilities. In R. J. Sternberg (ed.), *Advances in the psychology of intelligence: vol. 1, 181-205.*
Gelman, R. and Cohen, M. (1988). Qualitative differences in the way Down syndrome and normal children solve a novel counting problem. In L. Nadel (ed.), *The Psychobiology of Down's syndrome.* Cambridge, MA: MIT Press.
Gelman, R. and Gallistel, C. R. (1978). *The child's understanding of number*. Cambridge, MA: Harvard University Press.
Germain, R. (2002). A 'Positive' approach to supporting a pupil with Down syndrome during 'dedicated numeracy time'? *Down Syndrome: Research and Practice,* 8 (2), 53-58.
Gibson, D. (1996). Precognitive And Cognitive Resource Profiles: An 'Abilities' Approach to Biobehavioral Remediation. In B. Stratford and P. Gunn (Eds.) *New approaches to Down's syndrome.* London: Cassell.
Hanrahan, J. and Newman, T. (1996). Teaching addition to children. In B. Stratford and P. Gunn (Eds.) *New approaches to Down's syndrome.* London: Cassell.
Hulme, C. and Mackenzie, S. (1992) Working memory and severe learning difficulties. Hove: Lawrance Erlbaum Associates.
Jarrold, C., Baddeley, A., and Phillips, C. (1999). Down Syndrome and the phonological loop: the evidence for, and importance of, a specific verbal short-term memory deficit. *Down Syndrome: Research and Practice,* 6 (2) 61-75.
Keeler, M., and Swanson, H. (2001). Does strategy knowledge influence working memory in children with mathematical disabilities? *Journal of learning disabilities, vol. 34, 5, 418-434.*
Lewis, A. and Norwich, B. (1999). *Mapping a pedagogy for special educational needs*. Coventry: Institute of Education, University of Warwick, Exeter, School of Education.
McConkey, R., McEvoy, J. (1986). Games for learning to count. *British Journal of Special Education,* vol. 13, 2, 59-62.
Nye, J. Clibbens, J. and Bird, G. (1995). Numerical ability, general ability and language in children with Down's Syndrome. *Down's Syndrome: Research and Practice, 3* (3), 92-102.
Nye, J., Fluck, M. and Buckley, S. (1997). *Spontaneous production of number language by children with Down syndrome and their parents.* Poster presented at the end of 2nd international conference on language and cognitive development in Down syndrome, 8-10 April, University of Portsmouth, UK.
Nye, J., Fluck, M. and Buckley, S. (2001). Counting and cardinal understanding in children with Down syndrome and typically developing children. *Down Syndrome: Research and Practice, 7 (2), 68-78.*
Oliver, B. and Buckley, S. (1994). The language development of children with Down's syndrome: First words to two-word phrases. *Down's Syndrome: Research and Practice*: *2 (2), 71-75.*
Pitcairn, T. K. and Wishart, J. G. (1995). Reactions of young children with Down's syndrome to an impossible task. *British Journal of Developmental Psychology*, 12, 485-490.
Porter, J. (1999, a) Learning to count: a difficult task? *Down's Syndrome: Research and Practice*, vol. 6, 2, pp 85-94.
Porter, J. (1999, b). The attainments of pupils with severe learning difficulties on a simple counting and error detection task. *Journal of Applied Research in Intellectual Disabilities.* Vol. 12, 2, 87-99.

Purser, H. R. and Jarrold, C. (2005). Impaired Sort-term memory in Down syndrome reflects a capacity limitation rather than atypically rapid forgetting. *Journal of Speech, Language, and Hearing research, Vol. 48, pp. 172-188.*

Roberts, J.; Long, S.; Malkin, C; Barnes, E; Skinner, M.; Hennon, E.; and Anderson, K. (2005). Acomparison of phonological skills of boys with Fragile X syndrome and Down syndrome. *Journal of Speech, Language, and Hearing research, Vol. 48, pp. 980-995.*

Shepperdson, B. (1994). Attainments in reading and numbers of teenagers and young adults with Down's Syndrome. *Down's Syndrome: Research and Practice*, 2 (3), 97-101.

Sloper, P., Cunningham, C., Turner, S. and Knussen, C. (1990). Factors related to the academic attainments of children with Down's syndrome. *British Journal of Educational Psychology*, 60, 284-298.

Starkey, P., and Gelman, R. (1982). The development of addition and subtraction abilities prior to formal schooling in arithmetic. In T.P. Carpenter, J. M. Moser and T. A. Romberg (Eds.), *Addition and subtraction: A cognitive perspective*. Hillsdale, NJ: Lowrence Erlbaum.

Thorley, B. J. and Woods, V. M. (1979). Early number experiences for pre-school Down's syndrome children. *Aust. J. of Early Childhood*, Vol. 4 (1), 14-20.

Wilson, K. and Swanson, H. (2001). Are mathematics disabilities due to a domain-general or a domain-specific working memory deficit? *Journal of Learning Disabilities,* vol. 34, 237-248.

Wishart, J. G. (1993). The development of learning difficulties in children with Down's syndrome. *Journal of Intellectual Disability Research, 37, 389-403.*

Wishart, J.G. (1996, a). Learning in Young children with Down's syndrome: Developmental trends. In J. A. Rondal, J. Perera, L. Nadel, and A.Comblain. (Eds.). *Down's syndrome, Psychological, Psychobiological and socio-educational perspectives. London: Whurr publishers.*

Wishart, J. G. (1996, b). Avoidant Learning Styles And Cognitive Development In Young Children. In B. Stratford and P. Gunn (Eds.) *New approaches to Down's syndrome.* London: Cassell.

Wishart, J. (2001). Motivation and Learning styles in young children with Down syndrome. *Down Syndrome: Research and Practice*, 7 (2), pp. 47-51.

Wynn, K. (1992). Children's acquisition of the number words and the counting system. *Cognitive Psychology, 24, 220-251.*