The Problems of Diagnosis and Remediation of Dyscalculia

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There has been much emphasis in the U.K. on the development of both language and mathematics. In England, this has been demonstrated most recently by the British government's introduction during 1998 of prescribed 'literacy and numeracy hours' in primary schools. In practice, however, when it comes to Special Educational Needs (SEN) provision, equal status does not seem to be accorded to them.

Even the Department for Education's code of practice for SEN (DFE, 1994) lays greater emphasis on language. Indeed, specific learning difficulties, as a whole, appear under the heading '*Specific learning difficulties (for example Dyslexia)*' and, under that heading, numeracy and mathematics are mentioned only once each. In contrast, there is constant reference to reading and other language problems. The term 'dyslexia' is commonly known to describe a specific difficulty with language, but the parallel term 'dyscalculia', which describes a specific difficulty with mathematics, seems largely unheard of. There is a wealth of literature on the former, but a paucity of information on the latter. If our society does value numeracy as highly as literacy, then SEN provision should be more balanced between the two subjects.

This article is concerned with the problems of diagnosis and remediation of dyscalculia (see Underhill, 1987; Ashlock, 1987). It explores whether there is justification for believing that a specific difficulty with mathematics arises jointly with a specific language problem, or whether a specific difficulty with mathematics can arise independently of problems with language. A case study is used to illuminate the problems faced by a dyscalculic and to identify some of the specific learning problems faced by dyscalculics and strategies used by a teacher experienced in this field.

Dyscalculia – a definition

For the purposes of this article, the term 'dyscalculia' is used to mean *developmental dyscalculia* as defined by Dr. Ladislav Kosc (1986). Others have used the term to describe more generally any child with severe difficulty in learning mathematics. The reason for choosing Kosc's definition in this instance is not only its precision but also that it offers a parallel with one of the main definitions of dyslexia, and this in turn allows for some of the arguments about dyslexia to be more readily generalised to dyscalculia. Kosc's definition states that:

> Developmental dyscalculia is a structural disorder of mathematical abilities which has its origin in those parts of the brain that are the direct anatomico-physiological substrate responsible for the maturation of mathematical abilities adequate to age without, however, having as a consequence a disorder of general mental functions. The origins may be either genetic or acquired in prenatal development. (p. 48)

Kosc's definition of developmental dyscalculia regards its origins as genetic or prenatal, which means that it is attributed to physical development of the brain. In consequence, it is differentiated from *acalculia* (see Rourke and Conway, 1997), which is difficulty with mathematics or arithmetic as a result of brain damage in later life. The reason for this distinction is that having had a specific ability with mathematics - and then losing it due to trauma - may be qualitatively different, in terms of brain function, from not having the capacity to acquire that ability in the first place. This may have implications for remediation.

Importantly, a person is only acknowledged as having developmental dyscalculia if his or her general mental functioning is unaffected. In practice, since these general mental functions must be measured, this means that there must be a significant discrepancy between a measure of IQ and some measure of mathematical ability. Regarding children, Kosc's reasoning is that it is not possible to ignore the developmental aspects of readiness and maturation in defining the disorder. However, he goes on to say that this must not be confused with the effects of inadequate schooling or failure of the child to fulfil his or her potential because of "neurosis, objective illness or momentary indisposition" (p. 50), which represents underachievement and not dyscalculia.

Learning and cognitive style

An account of cognitive style is given by Mahesh Sharma (1986) who proposes a continuum of mathematical learning personalities with the qualitative and the quantitative forming opposite ends of the spectrum. The quantitative personality is claimed to be predisposed to deal with information in a sequential manner as opposed to the qualitative personality which is predisposed to deal with information holistically. In mathematics, broadly speaking, the quantitative style may be said to be more suited to activities such as performing algorithms or algebraic tasks and the qualitative style being more suited to seeing an overall approach to a solution or to solving spatial problems. A successful mathematician will need to be able to move fluently from one style of thinking to the other as occasion demands.

The significance of learning style to developmental dyscalculia is as follows. If the preferred learning style inclines a dyscalculic to use that part of the brain which is impaired, then it is likely that the effects of that impairment will be exacerbated. Conversely, if the preferred learning style favours the normally functioning parts of the brain, then the effects of any impairment will be diminished.

Furthermore, if learning style can be directed, then an option for remediation consists in influencing it so that the normally functioning parts of the brain are favoured. As the hemispheres are separated, abnormalities of the brain may be localised in one hemisphere only, thus affecting just one learning style. However, to be fluent in mathematics requires the thinking styles associated with both hemispheres. So, according to Kosc, this is the most to be hoped for:

> When dealing with a genuinely dyscalculic child, the goal of his correction is not, and cannot be, a full normalisation of his knowledge and skills in mathematics. The goals are to achieve his gradual adaptation to the demands of school and of life. [...] In our experiences the accomplishment of these goals is not very easy. (p. 88)

A case study

Ellie, a thirteen-year-old girl, was observed for approximately half-an-hour on each of four occasions. Two years earlier, she had been diagnosed as a developmental dyscalculic. Ellie was in year 8 of a secondary comprehensive school, and was placed in the top set for all subjects except for French, where she was in the second set. Jan Poustie, her specialist remedial teacher, classified Ellie as having a qualitative learning style, being more inclined to tackle problems holistically.

Ellie's reading speed was measured at 500 words per minute, with a good comprehension of what she read. Such a high figure was backed up during the case study observation in that, whilst taking a diagnostic test of mathematical ability, Ellie was often answering questions before they had been fully read by the observer - and could immediately justify her answers with a reasoned reference to the text.

However, such impressive figures for reading masked an underlying difficulty that was unlikely to be noticed by a teacher in a normal secondary school classroom situation. Ellie, despite instruction, had been unable to master a phonological approach to reading. She had to memorise each word separately, even to the extent that words with the same root but different endings were not associated but learnt as completely different words. It was estimated that Ellie need only see a new word three or four times before recognising it, indicative of an excellent visual memory.

Session 1

During this session, Ellie was observed whilst she completed Sharma's 'Diagnostic assessment of mathematics potential and achievement' test, which was administered by a person trained in its use. The test consisted of thirty written questions many of which included diagrams and most of which were based around variations of classic Piagetian development tests, such as conservation of volume and class inclusion. Ellie read the questions and answered orally with appropriate questions being offered as necessary to clarify intended answers. Ellie answered rapidly, taking approximately fifteen minutes to complete the whole test.

The first question that she failed to answer correctly was on class inclusion; when asked if there were more seagulls or seabirds, Ellie was adamant that it was impossible to tell without knowing both the number of seagulls and the number of seabirds. It is, of course, possible that she did not realise that seagulls are a type of seabird and hence was not in a position even to consider one as a subset of the other but, considering her profile above, this is probably not a likely explanation.

Questions concerning the conservation of volume produced what can be considered as the most startling results. The first such question showed diagrams of the classic Piagetian conservation of volume of liquid task: the liquid from a short, fat container shown being poured into a tall, thin container. Ellie was very insistent about her answer, and provided justification that the taller container had the greater amount of liquid in it - that the amount of liquid had in fact changed. On all similar conservation of volume questions she answered incorrectly.

In terms of Piagetian stages of development of conservation, the concept of volume should be achieved during the concrete operational stage which generally takes place between the ages of seven and eleven (see Slavin, 1994). According to Sharma's diagnostic test (see Table 1), the conservation of volume concept should be attained by nine years of age. Interestingly, Ellie appeared on other occasions to have grasped conservation of mass which is generally regarded as more difficult to grasp than conservation of volume. This was attributed to the fact that Ellie had been able to spend a lot of time in earlier years playing with play-dough whereas, because of her dyspraxia, she had spent relatively little time pouring liquids.

The test results for Ellie on the Sharma's test were:

Sub-Skill	Number of Items Correct	Number of Items in this Section	Age by which this skill should be completed
Volume	0	3	9 years
Spatial orientation and organisation	5	6	5–12 years
Classification	1	3	7–12 years
Number	2	3	6 years
Number Isolation of Variables and their Relationship	2	3	11–12 years

Table 1

Although there were thirty questions on the test only eighteen are recorded here; the other twelve questions fell into areas of sub-skill where Ellie made no mistakes, representing foundation skills that Sharma has identified as pre-requisites for adequate mathematical performance.

Session 2

In this session, Ellie played a game called Rummikub. From a mathematical perspective, Rummikub can be used to help develop a flexibility of thinking with respect to the way in which information can be classified. This was chosen because of the problems Ellie had with classification, as identified in Session 1

Rummikub is similar to the card game Rummy, and is a game that Ellie knew well. It consists of a set of tiles, each with a number from 0-13 printed on it, all numbers coming in different colours, the object being to lay down face up on the table groups of no less than three tiles. On taking a turn the player can use tiles from their own hand and/or tiles from existing groups, as long as the groups left on the table consist of no less than three tiles Groups can consist of either consecutive numbers of the same colour or of the same number in any different colour.

Ellie was very fast at spotting possible combinations and outperformed the observer on each of three games. Since Ellie performed well at this concrete game and yet scored poorly on the classification aspect of the Sharma test, it would appear that either:

(a) she had acquired concrete skills in the area of classification but was unable to transfer them to a more abstract written situation; *or*

(b) the skills she had acquired were highly specific to this game.

Session 3

After observing the first two sessions, the authors asked to be allowed to try to teach the concept of conservation of volume with an approach that was unfamiliar to Ellie. She was unable to see that pouring a liquid from one container to another did not affect the volume

A balloon was filled with water and given to Ellie. She was asked to say how much water was in the balloon Having decided she could not tell exactly, an agreement was reached that it contained 1/2 litre She was then asked to squeeze the balloon into various shapes, to squash it on the table and to fit it into a cup. The balloon was also twisted it into a dumb-bell shape, so that the water was at either end

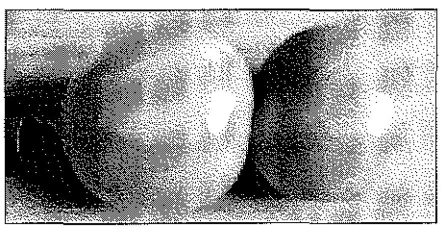

Figure 1

After each new shape was formed, Ellie was asked how much water was in the balloon. Each time, she replied 'half a litre', and each time was asked 'why?' The reply was always, "because it's the same, nothing's changed": this was always said as if it were totally obvious. Ellie was then allowed to burst the balloon into a cup, and the session ended. The total time spent was about ten minutes.

During the course of the next week, Ellie's mother reported having observed her in the kitchen Ellie was about to pour away a drink but then hesitated and poured the drink into another glass, she was then heard to say, "it's the same". This observation indicates two things:

- that Ellie had not previously grasped the conservation of volume, thus confirming the result of Sharma's test, which used diagrams;
- that Ellie had internalised, or was beginning to internalise, the concept

Ellie's understanding of the conservation of volume was subsequently tested and, some three months later, she seemed to have retained the concept.

Session 4

There were four distinct episodes to this session, and during the first three Ellie was observed working with a teacher.

The first episode, lasting about 10 minutes, consisted of training and testing of short-term memory. Knowing that Ellie had problems mastering a phonological approach to reading, having to memorise each word separately, a toy called 'Wizard' was used This had four buttons arranged in a circle, each button associated with an adjacent bank of lights and a different sound In one of its modes, the 'Wizard' produced a random sequence of flashing lights simultaneously with their associated sounds, the aim being to reproduce the sequence by pressing the buttons

Each time a sequence was reproduced correctly the 'Wizard' repeats the same sequence, but increases its length by one; failure to correctly reproduce the sequence ends the 'go'. The initial sequence was of length one Ellie was able to reproduce sequences of about six or seven in length whereas, from experience, most people (aged eleven or over) are able to reproduce sequences twelve or thirteen long.

Care must be taken when looking at these figures since they are not necessarily indicative that Ellie had a poor short-term memory, but may have something to say about how she was organising information. Adopting an information processing model of memory, Slavin (1994) suggests that short-term memory (STM), has a capacity for between five and nine bits of information (see Miller, 1956). In view of this, Ellie's STM for the 'Wizard' task could be described as within the normal range - but then why do most people seem to remember a sequence as long as twelve or thirteen items on this task?

A possible explanation can be given by the idea of 'grouping' or 'chunking' of information, meaning the combining several pieces of information to be memorised as one composite whole. For example, if presented with a random list of letters and spaces, it would be expected that, at most, nine letters and spaces could be held in STM. However, if presented with a list of totally unconnected words, it would be expected that five to nine words would be held in STM which, if the spelling was correct, represents approximately 30-54 letters and spaces (the English language has on average six letters per word, including spaces)

In the latter case, letters and spaces have been 'chunked' together in meaningful groups (words) thus, indirectly, significantly increasing the capacity of STM Whilst watching Ellie perform the 'Wizard' task the observer found himself listening to the four different pitches of sound produced and trying to remember the sequence as a tune or, at least as groups of musical 'phrases' - the flashing lights served as a constant reminder as to which button produced which sound. Using this form of 'chunking', the observer found that remembering sequences of greater length than seven presented no problem.

It may be that many people use a similar 'chunking' technique for the 'Wizard' task, whereas Ellie does not. Evidence that this might be the case was given in the notes that the teacher made with the results of Ellie's diagnostic test, saying that she was: "prioritising pictorial to the detriment of textual (and auditory) information". A later conversation with the teacher confirmed that she saw low scores on the 'Wizard' as demonstrating a non-integration of auditory and visual information.

The second episode, lasting about five minutes, involved Cuisenaire rods. Since Ellie was having a problem with the 'fluid' nature of the conservation of volume, it was felt that Cuisenaire rods provided a more concrete model for work on ratio and fractions. Cuisenaire rods have a square cross-section measuring 1cm x 1cm.

Ellie had worked with Cuisenaire rods extensively and knew the relationships that:

> 5 white rods are equivalent to a yellow rod;
>
> 10 white rods are equivalent to an orange rod;
>
> 2 yellow rods are equivalent to an orange rod

The teacher first established a value for the orange rod (10 cm) She then put a white rod (1 cm) next to the orange and asked Ellie what value the white represented. After Ellie had answered, the white rod was replaced with a yellow rod (5 cm) and she was asked what value the yellow represented This was repeated for several values given to the orange rod

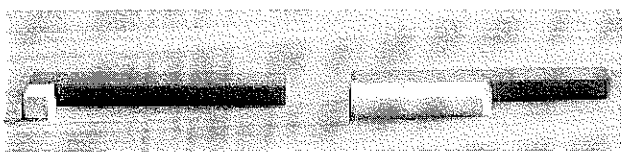

Figure 2

On the first occasion, the orange rod was designated the value of 1,000. Ellie quickly, and correctly, identified the values of the white and yellow rods as 100 and 500 respectively The orange rod was subsequently designated the values of 100 and 10 and again, on both occasions, Ellie readily and accurately identified the values of both rods

However, when the orange rod was designated as having a value of one, Ellie looked confused and, presumably anticipating the next question, asked what was meant. After some difficulty, she incorrectly identified the white rod as 'a twoth', although she did manage to identify the yellow rod as a half. Ellie appeared to be becoming frustrated at this point and the teacher decided to move on

From the exercise with Cuisenaire rods, it was clear that Ellie appeared uncomfortable about dividing a unit into parts, and by extension, with fractions. In particular, she was very unsure on how fractions are named Such difficulty at this level can be regarded as unusual given her age and apparent intelligence. But without knowing how she managed to arrive at the correct value for white and yellow rods when they had integer values, which could have been either by memory or some form of calculation or ratio-based reasoning, we are unable to draw further inferences.

The third episode, lasting about 10 minutes, involved the written addition of fractions Ellie was clearly having severe conceptual difficulty with the tasks set Her difficulties went as far as being unable to convert a mixed fraction to an improper fraction without instruction. Even then it seemed that she was executing a method without any real understanding of what she was doing. Since Ellie had not yet consolidated the conservation of volume concept this does not seem surprising.

If she had not yet fully appreciated that changing the appearance of a quantity of water did not affect its volume, it would be unrealistic to expect her to see how manipulating one abstract arrangement of numbers into another represented the same value. During this episode on one occasion, when asked to write down a particular fraction plus another fraction, Ellie wrote down x instead of +. The question was repeated three times whilst Ellie was looking at what she had written, but she did not spot the mistake until the third try

The fourth episode, during which fractions were introduced via a language-based approach, proved unsuccessful and had to be abandoned very shortly when Ellie started to become agitated. She reacted negatively to the task.

Comments

Possibly the most worrying aspect of this case study is that Ellie's problems had not been discovered at school The only cause for concern that would have been obvious in class was a difficulty with fractions - but a year 8 pupil who has difficulty with fractions is not unusual. However, what sense can Ellie make of typical explanations about the manipulation of fractions such as 'we are maintaining the value, but changing the appearance'? Without an adequate grasp of the conservation of volume concept such phrases must appear meaningless.

Unless Ellie's underlying problems that were identified in the diagnostic test were resolved, she would probably start to experience severe difficulty as the demand of the curriculum increased Algebra and trigonometry, for example, may well have proved very difficult. If her problems were not recognised then there was the very real prospect of the school seeing a top-set pupil, who had coped well so far, spiralling downwards without apparent reason.

It is worth considering that had Ellie not such a good visual memory for words, bearing in mind her phonological difficulty, she might be described as dyslexic.

Diagnosis and remediation

Kosc (1986) writes about the problems of diagnosis:

> Developmental dyscalculia is identified only from the fact that the child is unable to solve and resolve some particular tasks or problems in spite of special help (aids) from the diagnostician, or from the fact that he is employing inappropriate strategies to solve the task.

> When it can be objectively determined that the child is using ineffective mechanisms as a compensation for deficits in his ability structure, it is possible to infer the presence of a disturbance of the brain mechanisms. Eventually, these can be more or less localized within the structure of the brain. (p. 87)

Claiming 'every dyscalculic child is unique', he continues:

> remediation is aimed at developing individualized strategies for acquiring desirable, individually varied mechanisms of compensation at each level and in the various phases of the correction procedure. In this sense, it seems inadequate to elaborate and apply packaged programs for the correction of dyscalculic children's problems (p 87)

The principal concern here is with the mainstream mathematics classroom. The foregoing suggests that developmental dyscalculia can only be diagnosed and effectively remediated by specialists If this is the case, then ordinary classroom practitioners must merely aim to identify those potentially with the condition in order to refer them for outside testing and help A clear difference between a pupil's performance in mathematics and other subjects would indicate a cause for concern. But identification of risk is not necessarily that easy, as the case study of Ellie demonstrates.

If a pupil is currently coping adequately in class, taking into account general ability, then what is it that should give cause for concern? Perhaps mathematics teachers being aware of developmental dyscalculia and the sub-types listed by Kosc would at least lead to it being considered in individual cases, particularly if performance started to drop unexpectedly

Let us now consider remediation. It worth looking at the prospects of reading remediation for dyslexics. Pavlidis (1981) cites findings written by Schiffman from a dozen years earlier:

> if diagnosis of dyslexia is made within the first 2 grades of school, nearly 82% of dyslexic children can be brought back to normal grade classwork. When diagnosis is not made until the 3rd grade, salvage drops to 46%. By the 4th grade, it is down to 42%. If these children are not diagnosed by the 5th, 6th or 7th grades, regardless of the teacher or technique used, only 10 or 15% can be brought to a normal grade level (p 105)

What are the prospects for mathematics? Chinn and Ashcroft (1998) are of the opinion that all dyslexics have difficulties in at least some areas of mathematics They also claim:

> Experience teaching pupils from age 11 through to 16 seems to show that good early work pays huge dividends later Very few special approaches need to be used for 14, 15 and 16-year-olds who have been given a very sound foundation. It seems that they respond to conventional teaching methods. (p. 218)

In light of this, the prognosis for the mathematical difficulties that dyslexics face is brighter than that for their reading. It also appears that concrete teaching techniques can be helpful in the remediation process:

> Many dyslexic youngsters do become quite good at mathematics [...] It is possible that, because of a generalized weakness in language, dyslexics have difficulty with the process of concept formation itself Their thinking may remain embedded in concrete situations for longer than is usual with other children. The jump from concrete to abstract may happen less easily for them. (Kibel, 1992, pp. 46-47).

In Ellie's case, this is demonstrated by her difficulty with the conservation of volume and the remedial work undertaken in Sessions 3 and 4.

Discussion

This discussion centres around the ethical issues of whether dyscalculia and dyslexia should be given the same status within the educational system

The British Dyslexia Association (BDA) frequently quotes 4% of the population as severely dyslexic and up to 10% having some degree of the difficulties (Ott, 1997, p. 15). A study by Badian (cited in Rourke and Conway, 1997, p 34) shows the percentage of the population with difficulty in mathematics only is 3.6%, with reading only is 2.2% and with both mathematics and reading is 2.7%. A study by Joffe (1990, p 10) shows that 60% of dyslexics have difficulty with mathematics which is close to the figure of 55% given by Badian.

Identification of those with dyslexia has improved and many special needs departments give good remediation of reading difficulties. However, more needs to be done to test for dyscalculia when dyslexia has been diagnosed or is suspected.

A remaining problem is to identify the approximately 4% of pupils who have dyscalculia without associated reading difficulty. It must also be borne in mind that these are pupils with an IQ-performance discrepancy and that they will not be found exclusively in the bottom-set maths groups, as the case study of Ellie, who was in a top-set mathematics group, demonstrates This may be especially true for the lower age groups where an individual may be able to cope with mathematics due to compensatory intellectual strengths; again, the case study of Ellie bears witness to this.

If it is thought desirable that dyscalculics who have no reading difficulty should be identified, then the responsibility for referring these particular individuals for further assessment must lie with mathematics teachers. Neither should that absolve mathematics teachers from the responsibility of helping to identify the dyslexics who also have dyscalculia However, as was suggested earlier, this is not always an easy task. It may be clear that a pupil has problems but in such cases as Ellie's, it may be much harder to see, which clearly demonstrates the need to be vigilant of pupils' levels of understanding and not just to attend to their schoolwork performance.

Having just conferred certain responsibilities onto mathematics teachers, it must be acknowledged that many of them would not agree that it is necessary specifically to identify individuals with dyscalculia. This is particularly true if, as suggested earlier, dyscalculics perform in qualitatively the same way as ordinary poor mathematicians – in which case, assigning pupils to a set that is commensurate with their ability is arguably all that is required

Definitions of both developmental dyscalculia and developmental dyslexia focus on disorders of the brain. Dyslexia can be found in severe, moderate and mild forms (Ott, 1997) It would be reasonable to assume that the same type of range can be found amongst dyscalculics. So it can be seen that both dyslexia and dyscalculia lie on a continuum, which therefore suggests degrees of brain disorder. But where does the cut-off lie and what is a 'normal' brain?

If diagnosis of either condition is based on IQ-performance discrepancy, then the choice of magnitude of the discrepancy that defines a disorder is of a largely arbitrary nature. Furthermore, if it is not to be a pointless exercise, the rationale for diagnosis can only be to offer remediation or concessions in examinations. Dyslexics, for example, can be given extra time and help with reading questions or the use of a computer in some exams However, those that fall on the wrong side of the diagnostic divide gain fewer such benefits, and this raises some important ethical issues. Individuals of low IQ are less likely to obtain a diagnosis than those of high IQ on the basis of the IQ-performance discrepancies.

What about teaching methods? Ellis *et al.* (1996) found no qualitative difference between the reading of dyslexics and that of ordinary poor readers (that is, those with low IQ) From this, and views expressed by Joffe (1990), it can be argued that the same was possibly true for dyscalculics and ordinary poor mathematicians - that there is no qualitative difference in the way these two groups perform mathematically It can therefore be argued that the teaching techniques that are suitable for dyscalculics may also be suitable for other poor mathematicians So, it would seem reasonable to suggest that the teaching methods that are used for remediation of dyscalculics may usefully be incorporated into lessons for those of lower mathematical ability.

Conclusions

The limited evidence available suggests that the prevalence of dyscalculia may be on a par with that of dyslexia, approximately 6% of the population being affected by the former and between 4%-10% by the latter. If both literacy and numeracy are to be equally valued, then the implications are that general awareness of dyscalculia within the teaching profession should be raised to a similar level that of dyslexia; and that SEN provision for mathematics should be substantially increased to reflect these figures. It is important that mathematics teachers should be aware of the connection between the two syndromes

The symptoms of dyscalculia can be hard to spot (see Sharma, 1998; Underhill, 1987). Although some dyscalculics may consistently display errors that indicate an obvious cause for concern, others may appear to have no greater difficulty than many of their peers, but the underlying cause of their problems may be more deep-seated than is realised For this reason, amongst others, it is important to examine pupils' conceptual understanding of topics in addition to their performance.

It must be remembered that, as a direct consequence of the definition, the term *dyscalculic* is only applied to those who display an IQ-performance discrepancy; we must therefore guard against the natural tendency to make assumptions about an individual's fundamental understanding based on observations that they are 'bright'. Dyscalculia should certainly be considered as a possible cause when a pupil's performance in mathematics begins to degenerate for no immediately apparent reason. It is possible that a dyscalculic may have a compensatory ability, such as a facility with algorithms, that is capable of sustaining mathematical performance - until some critical point is reached.

The prognosis for successful remediation of dyscalculia is unclear. Kosc (1986) suggests that the aim of correction cannot be a full normalisation of abilities However, evidence of the success of Chinn and Ashcroft's work with dyslexics, a majority of whom one could infer to be dyscalculic, indicates that this may be overly pessimistic Furthermore, the teaching methods that are used for remediation of dyscalculia may well be of benefit to lower-ability mathematics groups.

In particular, the wide use of concrete materials for the explanation of concepts is of benefit. There is also reason to suggest that some of these methods may beneficially be incorporated into the secondary mathematics classroom more generally, and that this is worthy of further study. Although the case study of Ellie has been used largely for illustrative purposes, it became clear that, in some cases, teaching approaches can be successfully used to remediate dyscalculia.

Acknowledgement

We wish to thank Jan Poustie, a Special Need teacher with particular interest in mathematical difficulties, for her help and for allowing us to carry out the observations.

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