ISSUES IN IDENTIFYING CHILDREN WITH SPECIFIC ARITHMETIC DIFFICULTIES THROUGH STANDARDISED TESTING: A CRITICAL DISCUSSION OF DIFFERENT CASES

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The paper discusses issues related to the identification of children with extreme difficulties who are regarded as potentially having dyscalculia. We present cases of 7 year old children with different approaches to a standardised computer-based test. We present issues that the cases raise and reflect on how such tests can inform those who use them and whether they enable or not the identification of children's specific difficulties in arithmetic learning.

INTRODUCTION

The componential nature of arithmetical development is supported both by studies of children's individual differences which show discrepancies between different aspects of arithmetic ability such as between procedural, factual and conceptual knowledge, and by studies of children who experience severe difficulties in learning arithmetic (Geary and Hoard, 2001; Dowker, 1998). From a developmental perspective, this indicates that different types of arithmetic error stem from selective cognitive disorders that affect particular areas of the brain and result in impairments of specific aspects of arithmetic knowledge. The available research suggests that procedural knowledge and knowledge of arithmetical facts may develop in a semi-independent way and impairments may affect selectively different aspects of these types of knowledge. Very few studies in the area of developmental and neuro-psychology refer to difficulties with conceptual knowledge in mathematics learning (e.g. Delazer and Benke, 1997). While the most evidenced difficulties seem to be related with arithmetical facts, procedures and strategies, studies have also revealed that many children and adults seem to have difficulties with a wide range of different numerical tasks (e.g. Landerl, Bevan, & Butterworth, 2004). The available evidence is coming from research studies which have approached the issue of mathematics difficulties from many different perspectives, have used various methodological approaches, varying sizes of sample and identification tools and have also used a range of different terms for referring to difficulties that children and adults experience with mathematics learning (for a comprehensive review of research on mathematics difficulties see Gifford, 2005, 2006). One of the terms used is 'dyscalculia'. The Department for Education and Skills (DfES, 2001) has acknowledged dyscalculia and defined it as a specific learning difficulty that affects the ability to acquire arithmetical skills. However, the construct 'dyscalculia' is a highly controversial term not only because of the lack of understanding of what exactly 'dyscalculia' entails, but also because of the implications for children and the tools for identifying the specific learning difficulty.

RESEARCH RATIONALE AND METHODOLOGY

The project focuses on 6-7 year old children (Year 2) who experience difficulties in learning arithmetic. In the first phase of the research the first objective was to identify children who are particularly poor in arithmetic through discussion with their teachers and observation of children's work during the daily mathematics lesson. The second objective was to try to find out whether, within the group of children with low achievement in mathematics, there were children with severe difficulties in learning arithmetic due to factors other than social, emotional, behavioural etc. These could possibly be children who were achieving well in other areas of learning; children who could potentially have or being at risk of having 'dyscalculia'. In order to identify such cases we used the **Dyscalculia Screener** (Butterworth, 2003); a computer based, standardised test designed to diagnose dyscalculia in children aged 6 to 14 years and to distinguish this condition from other issues that can affect performance in mathematics such as difficulties in communication and interaction, behavioural, emotional and social development.

Brian Butterworth (2003) has suggested that 'the underlying cause for dyscalculia is related to disorders of the 'number module' of the brain, defined as the innate core of humans' numerical abilities' which categorises the world in terms of numerosities. According to this view 'the impairment in the capacity to learn arithmetic – dyscalculia – can be interpreted in many cases as a deficit in the child's concept of numerosity' (Butterworth, 2005, p. 15). The development of the Dyscalculia Screener (DS) by Brian Butterworth (2003) followed research with a small sample of 8-9 year old children with dyslexia and/or only dyscalculia. The main conclusion of this research was that children's difficulties in arithmetic were mainly related to difficulties in the cognitive ability for processing numbers. The screener is designed to identify deficiencies in specific capacities of numerosity and in numerical tasks which involve counting dots and comparing numbers. The speed of response is the measure used in the DS so the test is adjusted for slow reaction times. The screener comprises of: 1. Simple Reaction Time 2. Tests of Capacity (Dot Enumeration and Number Comparison -'Numerical Stroop') 3. Test of Achievement (Arithmetic achievement: addition and multiplication). Various concerns have been expressed about the use of the DS as an identification tool. Sue Gifford (2005) summarises some of these concerns and highlights the fact that the screener does not reveal difficulties with problem solving, strategy use and conceptual understanding. Moreover, the underlying assumption that slow response times at number processing indicates a neurological impairment is problematic as there may be children who are slow at processing numbers but perform well in other tasks or tasks which are not timed. Finally, recognition of numerals may be an isolated problem underlying cognitive deficit or other reasons like negative attitudes to both kinds of test.

We used the Dyscalculia Screener for the aforementioned objectives of the first phase of the project. Being aware of the reported concerns we also explored the differences and similarities in the way different children approached the testing experience and related these to their performance on the test and the screening reports that this generated.

THE SCREENING OUTCOMES AND CASES OF TWO PUPILS

The approach taken was to administer the screening program to children who were at the lowest mathematics set in their class; this excludes children who are statemented or SEN children. Altogether sixty Year 2 children from four (two primary and two infant) inner city schools in South England, were screened. Thirty-two of the children were girls and twenty-eight were boys. Thirteen of these children were from combined year 1 year 2 classes from two schools (g = girls; b = boys).

	School W	School S	School B	School SW
Yr 1/2	7 (3g, 4b)		6 (4g, 2b)	
Yr 2	15 (5g, 10b)	20 (14g, 6b)	7 (3g, 4b)	5 (3g, 2b)
Total	22 (8g, 14b)	20 (14g, 6b)	13 (7g, 6b)	5 (3g, 2b)

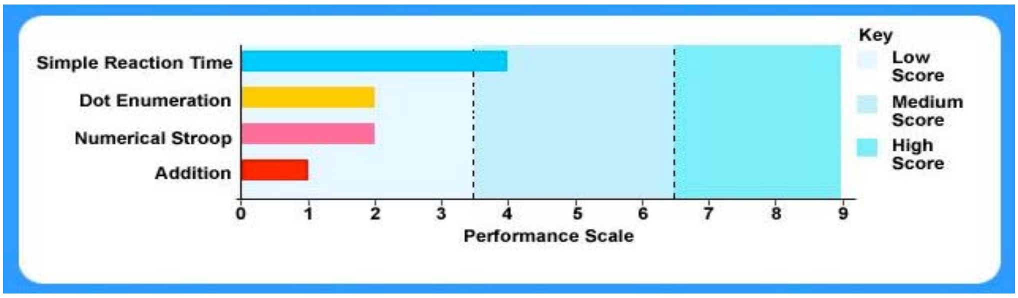
A preliminary analysis of the individual children's screener report showed seven main types of conclusions of the sample children's mathematics abilities. Aggregating the sixty children's results based on these reported conclusions gives:

Conclusion type	Numbers	%
a. Unlikely to have dyscalculia	12	20
b. Low achievement cannot be attributed to dyscalculia	16	27
c. Not failing in arithmetic because of dyscalculia	21	35
d. It is possible pupil is dyscalculic	2	3
e. Diagnosis of dyscalculia cannot be ruled out	1	1.6
f. Should be provisionally classified as dyscalculic	5	8
g. Pattern of results is evidence of dyscalculia	3	5

The three children with conclusion type "g" were all from the same school where two of the children were from the same year 2 class and the other from another year 2 class. To put context to the pupil's performance on the tests, and to further add to the pupil's profile, data from observations of the pupil as he/she worked on the tests is given together with data from the pre-screening oral tests which was carried out to ascertain pupils' mathematical knowledge and skills, and data on the pupil from classroom observations.

Case I: A pupil whose pattern of results is reported as evidence of dyscalculia: This pupil scored low on all tests. The screener reports that the pupil appears to be guessing on the Addition test and that this result should be treated with caution. The performance graph for this pupil is given below. Observation of the pupil, Sally, during these tests shows the following:

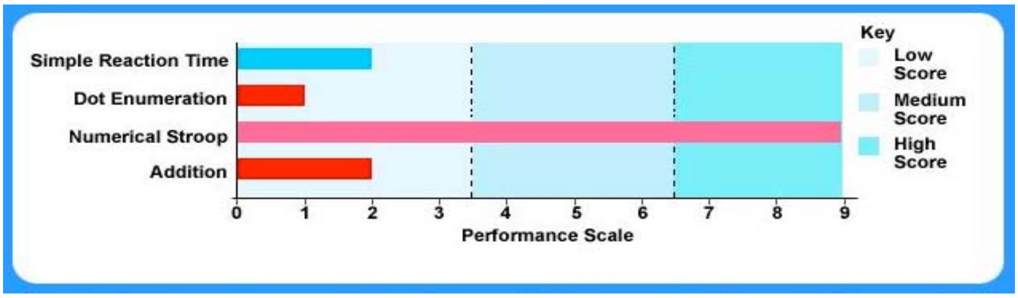
(i) *Dot Enumeration:* Sally understood the test and its requirement. During this test Sally counted the number of dots of every task. Her count and her responses were mostly correct. Sally's counting was slow, which she did by touching spots on the computer screen while softly verbalising the count. Sally appeared able to immediately identify the numeric count for patterns with one, two or three spots



without counting them. (ii) *Numerical Stroop test:* Sally's answers were mostly correct. Again, Sally worked through these tasks very slowly. Sally's clear hesitation on these tasks were (a) when the numbers to be compared were in reverse sequence, e.g. 3 & 2 or 4 & 3, regardless of the number size, and (b) when the numbers to be compared were in sequence but are 'big' numbers e.g. 7 & 8. Although Sally hesitates (4-5 secs) before answering her answers were often correct. (iii) *Addition test:* Sally worked out, or on many occasions tried to work out, the answer for each of the addition tasks; the screener however reports that Sally appears to be guessing on this test. Sally had difficulty working out answers for sums that totalled more than 10 due to her applied procedure. Her procedure is to count-out, or sometimes immediately model, on her fingers the first number in the sum, then count-out on her fingers the second number or addend, and then do a count-all of these fingers to arrive at the answer. Sally's difficulties are when she cannot complete her count for the addend due to insufficient fingers. This might be construed as guessing the answer but this would not have taken into account Sally's correct effort in attempting to work out the answer and her difficulty in completing it. In the pre-screening test, Sally correctly answered tasks on numeric comparison. For example, Sally said 8 is more than 1 "because it is not low. It is a high number".

Case II: A pupil who 'should be provisionally classified as dyscalculic': The screener reports that this pupil, Ursula, appears to be guessing on the Dot Enumeration and Addition test "because of an inability to answer the questions but other causes cannot be excluded". Ursula's performance graph is given below. Her performance on the Numerical Stroop is very high and in fact better than the performance of pupils who are reported as unlikely to have dyscalculia.

Observation of Ursula during these tests shows the following: (i) *Dot Enumeration test:* Ursula counted-out the number of spots for each task, saying "yes" when her count matches the given numeric value and "no" when they don't. Ursula however quite often presses the 'no' key to answer 'yes' and vice versa. Ursula's actions do not appear to be intentional because Ursula's frequent checks for the 'yes' and 'no' keys suggests that she kept forgetting which were these keys. Ursula therefore had not guessed on this test as implied by the



screener report. (ii) <u>*Addition test*:</u> Ursula does not appear to know how to work out totals below 10. Yet, the report shows a better performance on the addition test than Sally's. This observation is supported by her response "I don't know" when she was asked how she would work out the answer of a current task. Ursula either presses the 'yes' key, or asks "Is it [a number]?" where the numeric value would be one more than the given answer e.g. for 6+5=9 Ursula asked "Is it 10?" Ursula's demonstrated procedure for working out answers showed lack of knowledge of a correct procedure to work addition sums. For example, for 3+5=8 Ursula showed 3 fingers on her left hand and said "Do equals" and showed 3 fingers on right hand. Then she said "do 5" and showed 5 fingers on left hand. She said "Do add", and "four" was her answer. In the pre-screening task Ursula correctly answered questions on numeric comparison e.g. Ursula says 8 is more than 6 "Because 6 is smaller and 8 is bigger. Because it is 6, 7, 8. 6 comes first". In classroom observation Ursula was unable to write and work out the answer of addition sentences for two sets of multilink cubes. Ursula was also unable to give an answer to the question "I add something to make 2" based on the written sum '1+ __ = 2'.

EMERGING CONCERNS AND CONCLUDING REMARKS

Based on the above aggregated result "g", the outcome from screening is in line with what is reported in literature (e.g. Shalev *et al.*, 2000), which is that developmental dyscalculia ranges from 3-6% of the school population. Our concerns initially arise due to the only slight variation in the performance graphs between children when the screener's conclusions on their mathematics abilities are very different. The only variation between the two cases is in the results of their 'Dot Enumeration', where the difference might be due to many number of reasons, such as carelessness or lack of attention during counting, in addition to dyscalculic tendencies. Other concerns arise due to the lack of clear description of the basis or rationale on which judgement is made of children's performance on their given tasks. Would the speed at which a child responds to the tasks affect this judgement? Many children enthusiastically started an activity and responded promptly to the tasks but after several of the same type of tasks they either slowed down in their speed of response, or got distracted. So should the speed of response during the simple reaction time test have any bearing on the judgement of a pupil's performance? Secondly, what is the level of intervention and support permitted, if any, during administering the test? Can a child who was observed pressing repeatedly the wrong keys be reminded of the task requirements? Thirdly, observations of the children during their whole-class mathematics learning and observations of the children during the screening highlighted working characteristics or approaches that could significantly affect their test performance. Many of the children still use the count-all method on their fingers to work out their addition tasks. Sums that totalled more than 10 therefore were a difficulty for many of these children due to insufficient fingers. Mistakes were often made by some children who did not appear to closely monitor their counting-out of their fingers. These working characteristics contradict remarks made in the report such as "pupil appears to be guessing" and raise questions on how far this might influence the judgement made of the children's mathematics abilities. An aspect of the screener that appears to affect many children's performance is the number and repetitiveness of the tasks within each activity type. The other is the necessity of completing all the activities in one sitting. While a few children worked through and persisted with the many similar tasks within each activity uncomplainingly, several children became bored. Remarks such as "I am bored" and questions such as "When will this finish?" occur frequently. Several children needed persuasion to complete the tasks and the test. How significant is really the time element in completing the given tasks? In conclusion, the issues that the use of the DS have raised highlight the fact that the picture of a child as a mathematics learner whose errors and difficulties are sometimes not mathematical in origin cannot be captured or reflected solely in these results. This leads us to the question: How can such results be used and interpreted and what are the implications for children who are tested?

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