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DYSCALCULIA: ISSUES OF EXISTENCE, IDENTIFICATION AND PREVENTION

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Dyscalculia, although officially acknowledged, is controversial. It is particularly problematic for mathematics educators, involving evidence from non-educational paradigms and raising issues about inclusion, mathematics and learning. There are implications for research and the prevention of mathematics difficulties.

Dyscalculia is officially acknowledged in England as a specific learning difficulty (DfES, 2001) yet its existence, nature and prevalence are highly debatable. For mathematics educators, the idea of an innate number ability may seem farfetched: we can think of many other reasons, educational and emotional, to explain poor progress in mathematics. It is also a highly problematic concept, going against current views of mathematics and of learning. However, there is suggestive evidence linking specific brain areas with number processing. Parallels with dyslexia are commonly drawn, since similar issues of official diagnosis and support are involved: however, there are distinct differences. There an established view of dyslexia that a part of the brain is involved in phonological difficulties (Nicolson, 2005). However, discriminating sounds in words seems a perceptual process which is very different from discriminating numbers, which involves conceptual understanding. What then should be the view of mathematics educators regarding dyscalculia ?

WHAT IS DYSCALCULIA?

Historically, dyscalculia has been used to describe a specific learning disability with number, in children without general learning difficulties, caused by an innate abnormality of a part of the brain dealing with arithmetic (Kosc, 1974). The DfES definition of dyscalculia seems to echo this view by using the word ‘intuitive’:

> A condition that affects the ability to acquire arithmetical skills. Dyscalculic learners may have difficulty understanding simple number concepts, lack an intuitive grasp of numbers and have problems learning number facts and procedures. Even if they produce a correct answer or use a correct method, they may do so mechanically and without confidence. (DfES, 2001)

However, no test of brain abnormality exists and such characteristics are too ambiguous for the purposes of identification. Common methods attempting to identify a discrepancy between children’s intelligence and mathematics performance vary, for instance in arithmetic tests used, which may emphasise skills, speed or problem solving. Mazocco and Myers (2003) found half the children from grades one to three and half those in kindergarten could be identified with a mathematics learning disability using different methods. They stressed the need for assessment over time to distinguish delayed learning from a disability. A learning disability implies that a child does not learn when taught: identification should only be made when a child has received expert teaching addressing their difficulties over a period of time. Studies show children who appear dyscalculic can be taught: Dowker (2004) advises that small amounts of individual teaching can be effective with most difficulties, as recommended by Wave Three (DfES 2005). Mathematics difficulties is therefore currently a preferred term, avoiding issues of innate causes and self-fulfilling labels.

Confusion about identifying dyscalculia is reflected in government websites: while one states that no assessment tool is available to teachers (DfES, 2004) another recommends the Dyscalculia Screener computer test (PNS, 2005; Butterworth, 2003). This involves standardised speed tests for rapid dot counting and comparing the value of numerals: these are intended to detect innate difficulties by using basic number comprehension rather than taught performance. Such tasks have been found to be good predictors of mathematics difficulties with six year olds (Gersten et al, 2005). However, the use of cut-off scores such as the bottom 4% may just identify children at one end of the achievement range. Performance may reflect factors such as children's lack of early number learning experience: pre-schoolers' number learning is significantly affected by the socio-economic status of families and home learning environment (Sammons et al, 2002).

It is debated whether there are different kinds of dyscalculia caused by other difficulties such as dyslexia, dyspraxia or ADHD. Alternatively dyscalculia may just co-occur with other conditions. With no agreed identification method for dyscalculia, findings from studies, such as prevalence rates of 5%, are unreliable. The one agreed finding, possibly because most studies tested this, is a difficulty with remembering number facts.

NEUROLOGICAL CAUSES FOR NUMBER DIFFICULTIES

From studies of patients with brain damage and brain scans of people carrying out number tasks. an area in the parietal lobes (sides of the brain) is linked with number processing. Dowker (2004) evaluates this evidence: for instance, adult brain functions may not resemble those of infants, due to changes as a result of learning. While children may have neurological conditions, such as epilepsy, which are associated particularly with number difficulties, it is not clear what processes are affected. Prematurely born adolescents with learning difficulties only in arithmetic were found to have less grey matter in the left parietal lobe, suggesting a neurological cause from birth (Isaacs et al, 2001). However, it is not clear what their precise difficulties were: they could do simple addition and subtraction and mathematical reasoning, but they had serious difficulties with procedures involving borrowing and carrying. This raises questions about the methods children are taught and what is considered important in mathematics: if they used mental methods and calculators would they not have arithmetic difficulties?

There are two main theories about what an innate numerical brain functions might be. Butterworth suggests there is a for recognising numerosity or cardinality of numbers

Butterworth (2003) suggests a capacity for recognising cardinality of numbers up to three or four, including the results of adding or subtracting one. Apart from rare case studies of adults, the main evidence comes from studies of babies, who look harder when a new number of objects is shown to them. However, these have been challenged by findings that babies do not notice number differences if the surface area does not change, suggesting they may be tracking individual items, rather than recognising changes in number (Fiegensen et al, 2002). According to Dowker (2004) children who lack the ability to subitise three are very rare.

Dehaene's (2001) number sense theory suggests people automatically order approximate numerosities on a visuo-spatial number line. This is supported by a variety of evidence of the 'distance effect', that people find it easier to compare numbers which are further apart, like 8 and 4, rather than closer together, like 8 and 7. People react in the same way with numerals, words or dots, and similar effects have been shown with animals. People also automatically compare number values, so that when asked which numeral is physically larger, 7 and 9 is harder than the other way round. (This is one of the tests on the Dyscalculia Screener.) When asked to position numbers on a line, most children can accurately position familiar number ranges, but otherwise even adults tend to put smaller numbers close together and larger numbers further apart. Babies also seem able to compare bigger numbers of dots with large differences, such as 8 and 16, even when area is controlled. Brain scans show that the left parietal lobes are activated during approximate number tasks, whether presented verbally or symbolically, while exact responses activate other areas.

There are various arguments against such evidence. Just because people develop common ways of doing things automatically does not mean processes are innate. Babies may be responding to contrasts in dottiness, rather than number. Animals' brains may not resemble humans'. There are also more fundamental arguments about the assumptions underlying the idea of dyscalculia.

MEDICAL AND SOCIAL MODELS OF DISABILITY

Current views on inclusion criticise the medical model of disability, which stresses 'within-child' rather social and environmental factors, and places the medical profession rather than educationists in charge of diagnosis and provision (Lindsay, 2003). In contrast, a social model of inclusion regards society as creating disabilities by categorising individuals as abnormal. Dyscalculia fits the medical model, especially if it requires expert identification (as with a standardised test) and predicts children's achievement despite their efforts to compensate. This model also marginalises teachers' ability to make a difference and any belief in all children as educable. The social model, that extreme mathematics difficulties are caused by factors such as lack of teaching and loss of confidence, may seem more reasonable. However, it might be said that mathematics educators are bound to be sceptical, since dyscalculia challenges their role and beliefs. Lindsay also argues that a purely social model is in danger of ignoring children's problems and a more appropriate model is of interaction between ‘within-child’ and social factors over time. The interactive model fits examples from case–studies, where minor neurological problems can create mathematics difficulties and destroy children’s confidence, especially when combined or gaps in schooling (Kaufmann et al, 2003). Similarly children with spatial or verbal memory difficulties can compensate by using their strengths, whereas socially disadvantaged children may lack finger strategies or have language difficulties. A more complex model of mathematics difficulties therefore seems indicated.

VIEWS OF MATHEMATICS AND LEARNING

A single deficit model of number difficulties also implies a reductionist view of mathematics, as dependent either on ‘simple number concepts’ or number line models. Dowker has argued that arithmetic is not unitary and that children and adults can show contrasting strengths and weaknesses in almost any two aspects. Abstract concepts for small numbers are complex, since numbers have multiple meanings, as measures, labels and amounts, and also as relationships. Five may be a dice pattern and a position on a number line, one more than four and less than six, but also the total of three and two and half of ten. One person may not have the same concept of five as another, but a different network of connected meanings, some personal, like age or door numbers. The reductionist view of mathematics implies normalised number concepts rather than socially constructivist views of mathematical learning. It ignores cultural variations and mathematics as social practice, such as Asian finger representations of six using two fingers. Standardisation of ‘normal’ responses for young children ignores social disadvantage which creates large variations in experience, competence and confidence. It also ignores children as agents in their own learning, with purposes, identities and attitudes which affect their belief in their own capacity to learn arithmetic.

Dyscalculia therefore may challenge our views of mathematics. The idea that numbers are perceptions rather than concepts goes against ideas of mathematics as culturally constructed. It may also challenge views of mathematics as evidence of rational superiority. If we no longer believe in a Platonic view of mathematics, the idea that we are programmed to compare numerosities seems outdated. It implies that numbers are ‘ontologically prior to human perception and cognition’ (Hammersley, 2005). A culturally constructed view of mathematics implies that people develop abstract number concepts via symbols, which allow mental comparisons of equivalences. This view is supported by findings that children only solve exact number problems non-verbally when they know some number words and are able to symbolise. It is also supported by studies of Amazon Indians who cannot solve exact number problems beyond the range for which they have number words, even if this is only two (Gordon, 2004).

However, Dehaene (2001) suggests that we are naturally selected because of our ‘number sense’. Our mathematics matches the world well, because it uses appropriate innate representations and there is a socio-cultural selection of the mathematics with greatest usefulness in representing natural phenomena. Similarly ideas of 'embodied mathematics' suggest that the cognitive representational systems available determine the mathematical ideas that human beings can have.

PREVENTION OF DYSCALCULIA

In order to identify dyscalculia, it is therefore necessary to eliminate other physiological, educational and attitudinal causes and to show that children do not respond to appropriate teaching. With such individuals, more needs to be known about their difficulties, such as whether they lack cardinal concepts of numbers. However, innate causes of difficulties can only be guessed at until more is known about how numerical processes in the brain develop from birth. It therefore seems less misleading to refer to children as having mathematics difficulties and to define dyscalculia as on a continuum.

It seems more productive to consider prevention: some children may not have developed automaticity in counting and cardinal concepts for numbers through sheer lack of opportunity. In the US, prevention rather than intervention programmes target children at risk through social disadvantage, on the principle that this is better than even early intervention after difficulties have developed. This need not mean pressurising young children more, but ensuring that they have time to develop complete confidence and competence in synthesising early number understandings.

However, a purely social model may ignore some children's need to develop compensatory strategies, for instance if they have verbal memory or co-ordination difficulties. It is also important to remember the physical limitations of young children's working memory. A one size curriculum may not fit all and teachers need to be aware of possible cognitive diversity as one of many factors affecting mathematics learning. It also seems clear that more research is needed into individual variations in developing 'simple number concepts'.

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