

A Report of the

BRAIN RESEARCH AND LEARNING SCIENCES

Mini-symposium on the design of rehabilitation software for dyscalculia
20 Septembre 2003

Hosted by
INSERM Cognitive Neuroimager Unit, Orsay, France

Organisation for Economic Co-operation and Development



Centre for Educational Research and Innovation

The goal of this report of the Dyscalculia Symposium is to:

- Provide an overview of the content of the symposium.
- Present the results of the discussion on the development of rehabilitation software for the use of learners with dyscalculia.

N.B. This project on "Learning Sciences and Brain Research" was introduced to the OECD's CERI Governing Board on 23 November 1999, outlining proposed work for the future. The purpose of this novel project was to create collaboration between learning sciences and brain research on the one hand, and researchers and policy-makers on the other hand. The CERI Governing Board recognised this as a risk venture, as most innovative programmes are, but with a high potential pay-off. The CERI Secretariat and Governing Board particularly agreed that the project had excellent potential for better understanding learning processes over the lifecycle, but that ethical questions also existed. Together these potentials and concerns highlighted the need for dialogue between the different stakeholders.

The project is now in its second phase (2002-2005), and has channelled its activities into a three-dimensional approach: to concentrating on 3 main issues (problem-focused; trans-disciplinary; and international); within 3 networks (literacy, numeracy and lifelong learning); and in collaboration with 3 leading institutions (The National Science Foundation, The Sackler Institute, The Riken Brain Science Institute).

This symposium is the first of a series of small focus group meetings which have been proposed for the second phase of the Learning Sciences and Brain Research project, specifically designed to bring together a few researchers and practitioners around a particular problem or issue which might lead to cross-fertilisation across research areas, that might eventually drive innovations within the field.

Introduction

Stanislas Dehaene, INSERM France (the hosts of this meeting), began by outlining the goals for the day. OECD is about reviewing just as much as initiating new research, he said that this meeting was to focus on whether we can do something about kids with dyscalculia. The aim of this symposium was to bring together Scientific specialists in the fields of both dyscalculia (maths disability) and dyslexia (reading disability) in order to exchange their expertise and experience. Remedial tools that have already been pilot tested (and their outcomes), and others (notably computer software programmes) that are currently under development, in order to combat dyscalculia and dyslexia were presented. The outcome of this interchange is the hope to generate computer software programmes for dyscalculic children, as remedial tools, to be made available on a common platform for eventual download from the OECD's Brain and Learning website. The results of which will be captured and disseminated online.

The problem of dyscalculia, or difficulty with numbers and mathematical computation, has recently become a topical subject of concern. Feature articles on this subject have appeared in the popular journals "Time" and "Scientific American."¹ At last, there is recognition that maths is not just a subject which is notoriously hated by many children, but that this dislike can stem from real difficulties with numbers. As a result, children fail to understand their lessons, they fall further and further behind in the curriculum and are eventually excluded in the classroom by their teachers and classmates. They even go so far as to admit as to "feeling stupid." The long-term consequences are that they have to carry a problem which handicaps them throughout life. But just how prevalent is dyscalculia? Is it a brain/biological problem? How can it be detected? Is it possible to overcome with remediation, and is there a dyscalculia genotype?

Firstly, the question of "what is dyscalculia?" was discussed upfront at the meeting. Dyscalculia is a clear brain problem, like dyslexia. It is caused by a weakness in the neuronal structures and pathways that underlie the very concept of numbers that, to a "normal" brain seem so intuitive. Educators often despair when they hear that a problem is brain related, and say that there is nothing they can do about it. However, it is this unambiguous classification of dyscalculia as a "brain problem" that actually offers hope for specific remedial training based on brain science's understanding of the neuronal structures and pathways underlying the very concept of numbers.

The differences between dyscalculia and dyslexia were also raised, and it was generally agreed that these are two separate problems involving different areas of brain dysfunction. Testing in the UK found that children, whose scores showed evidence of maths disabilities, were not as a consequence of reading disabilities, slow reading or poor language abilities². However, there are cases where persons are afflicted with both. It is however, important to note, that dyslexia also handicaps many other subjects where reading comprehension is necessary, including tackling mathematical problems. Experts in both fields agreed that children and adults alike with reading and number difficulties could overcome, or greatly improve, with rehabilitation programmes.

¹ Time Magazine, 28 July 2003, Scientific American, September 2003, Vol. 289 N0 3

² See Brian Butterworth's presentation.

An hypothesis for dyscalculia



When there is a realisation that multiple representations of numbers all have the same meaning (the Arabic digit "2", the quantity "2" and the word "two") there is an "epiphany" in the child's brain.

Stanislas Dehaene, INSERM, France

For Stanislas Dehaene, INSERM, France, it all began with a cognitive model of how numbers work. He presented his hypothesis as to the cerebral structures that are engaged in mental arithmetic, backed by numerous imaging and cognitive studies (notably the new evidence for "number neurons" in the monkey brain, which bears a significant homology to the human brain). His hypothesis is based on a "triple code" model of the brain³. This model attempts to show that depending on which arithmetic processes is being undertaken, information moves back and forth within these subsystems, recruiting one, two or all of them (see figures 1 & 2 below).

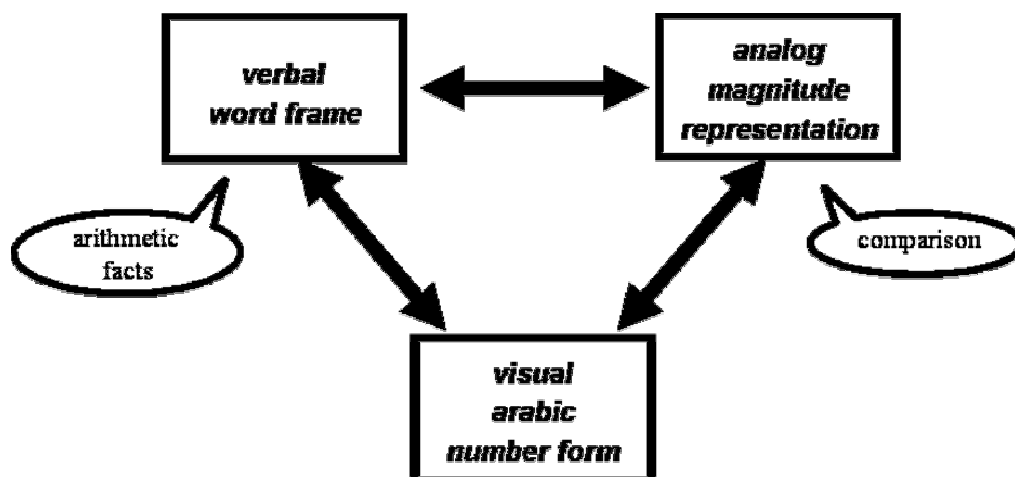


Figure 1

³ See also the following OECD Reports: The First High Level Forum on Brain Mechanisms and Early Learning Report, Section 5.1.1. Learning Arithmetic, and Appendix K in the Brocton Report on the Literacy and Numeracy Network Deliberations.

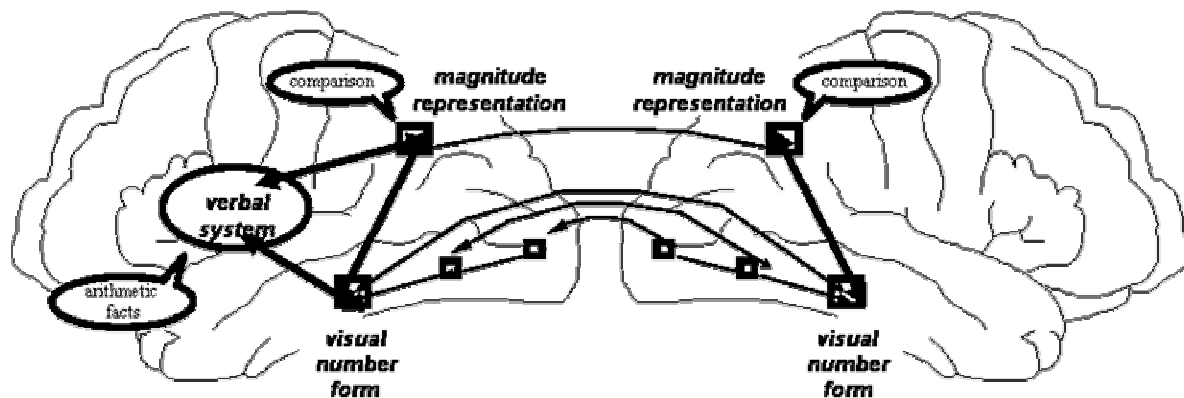


Figure 2

Children must learn to associate 3 representations of each number: the Arabic digit "2", the quantity "2" and the word "two". Each of these lies in a separate neuronal network. The major progress is that we now know much more about how these networks are implemented in the brain, and in particular about the core system of "number sense" which seems to be systematically associated with the left and right intraparietal regions. During the acquisition of arithmetic, the child must develop precise neuronal connections between this region and other brain regions involved in recognizing and producing Arabic and verbal numerals. During development, the "number sense" is also refined by progressively sharpening a pre-existing understanding of numerosity into a "number line" which specifies the relationships of numbers among themselves (greater-than, etc.). When there is a realisation that all quantities map onto number symbols and vice-versa, there is an "epiphany" in the child's brain.

How is this knowledge of normal number development relevant to dyscalculia? If the pre-existing "number sense" is weak, perhaps because of a neurological insult or an environmental deprivation, then the current thought is that this may cause dyscalculia. A number of studies show, in either single cases or in groups of subjects, that many children with dyscalculia have missing gray matter or other neurological insults in the intraparietal sulcus, at the precise location thought to be engaged in number sense in normal children; so it suggests that if you have a problem in this area early on you might have dyscalculia. Girls with Turner's syndrome, a genetic disease caused by a missing X chromosome, shows disorganisation of this area which seems to be related to dyscalculia. More systematic studies on this are needed to understand the extent to which this is true of all dyscalculics, or whether there are subtypes of dyscalculias. We need also to find families with dyscalculia to be able to study and to make progress on genetics and development of these areas.⁴

But what can be hoped for rehabilitation? When educators hear the problem is in the brain they drop their hands in despair. This reaction, of course, ignores the possibility of brain plasticity and therefore the likelihood that these functions are not necessarily permanently impaired and can be restored by training. Dehaene is hopeful that there is maturation in the quantity system and that it is dependent on the training we give children. Note, however, that we still ignore the exact nature of the neurological problems in dyscalculia (nor their frequency). Perhaps the problems

⁴ See also the OECD Brocton Report on the Literacy and Numeracy Network Deliberations: Early markers of dyslexia where Heikki Lyytinen of Finland presented his discovery that event-related (ERP), to speech stimuli immediately after birth, as well as those recorded at 6 months of age, reveal significant correlations to later language development and reading acquisition.

children have are to do with the local organization of the parietal cortex, or perhaps they are related to the connections of this “number sense” to other brain regions. We simply do not know yet to what extent these problems will be changeable with an appropriate rehabilitation.

Discussion

Brian Butterworth mentioned a study in Rochester on adults or kids playing computer games, where the results show that the attentional skills improve considerably. Dehaene says we can certainly learn from this and aim to try to engage the child as much as possible.

Diana Laurillard asked if going into the genetic origins will help with rehabilitation? Dehaene responded that the purpose of this is more to understand the biological origins of the problem.

Dehaene ended by saying that the role of symbols needs to be looked at. He stressed that due to the fact that number is such a basic intuition, it is very hard to place ourselves in the heads of dyscalculic children.

What has been learned from a reading intervention, and the role of neuroimaging measures?



Acquiring literacy is not a biological pathway. We are building from old parts to create connections, so as to assure efficient communication between different areas in the brain.

Bruce McCandliss, Sackler Institute, USA

Bruce McCandliss, Sackler Institute, USA, began his presentation by saying that there is a great overlap between literacy and numeracy acquisition and disorder. Unlike walking or talking, reading is not a biologically prepared ability that spontaneously emerges in normal development. Rather, there is a case to be made that this skill is built, through training and experience, from old parts connected together in new ways, so as to assure efficient communication between different areas in the brain. Neuroimaging has shown that dyslexics fail to activate the left peri-sylvian region of the brain associated with word sounds, and left visual areas associated with the visual form of words. There also appears to be a large genetic contribution to dyslexia. Children that experience difficulty with tasks that involve playing with the sounds of words, such as pig Latin or rhyming, have problems linking graphemes (single letters) and phonemes (basic units of speech) in service of learning to read words. A lot has been learned from reading interventions. McCandliss mentioned one study on children with poor decoding abilities, who fail to produce pronunciation of a string of letters.

McCandliss' hypothesis is that by systematically drawing such children's attention to letter-sound mappings within words, gradually building this skill has transfer effects that lead to:

- Increased abilities to incorporate all letters of a word into a pronunciation;
- Increased skill at reading novel words (pseudo words);

- Increased reading comprehension scores
- Increased phonological awareness and phonological skills.

He further hypothesizes that such training leads to increased recruitment of the left perisylvian regions during simple reading tasks that do not explicitly require phonological analysis, but may nonetheless engage such processes in skilled readers.

Phonological deficit are typically central to most reading problems, so to reach the “heart of dyslexia” one has to work on building up processes that rely on perisylvian regions. By engaging in systematic alphabetic decoding successfully, children engage in a form of *self-teaching* that strengthens these phonological systems that support reading. One approach to intervention is to help children with reading impairments successfully engage in this form of self-teaching, strengthening phonological systems, and ultimately increase recruitment of these brain regions.

McCandliss then presented Isabel Beck’s Word Building intervention programme⁵, which he showed helps dyslexics work on the grapheme/phoneme relationships to make up the word form. Letter sound units are placed on cards; words are represented as temporary combinations of familiar letter cards. Attention is focused on one letter within each new word to make new pairings. Over about 20 sessions which focus on one grapheme at a time, the difficulty is continually tested and modified accordingly. There is a high success rate of 70-80% within each lesson, which is very motivating for the children. There were significant gains in decoding ability (sounding out new words), reading comprehension as well as phonological awareness.

Discussion

Brian Butterworth posed the question as to what the waiting list control group kids who participated in the same intervention the following semester did whilst on the waiting list. McCandliss answered that the kids on the waiting list were encouraged to explore other remedial methods.

Butterworth then asked “How do you know kids were engaged more in self teaching?” McCandliss said there was a notable improvement in pseudo word reading.

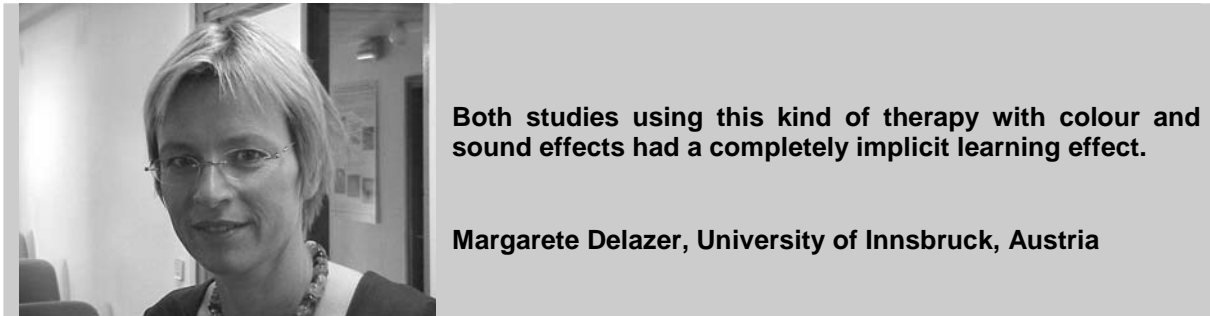
Bruno della-Chiesa asked if it were useful to add a gesture component to the Word Building method to reinforce the visual and auditory areas of the cortex by adding a sensori-motor cortex component to the learning process? McCandliss said that they did explore different methods to help to focus attention on a phoneme, to achieve the same goal.

Sharon Griffin asked if there were any particular problems experienced with low SES kids using this intervention (see her presentation in this report). McCandliss answered by saying that a low SES group is one problem in reading acquisition, and these may be compounded by largely separate factors associated with biological problems in learning to read. This is an important issue for this group to consider in their approach. Should we restrict our focus to biological problems in learning to read and compute with numbers, or should we also incorporate scientific approaches to understanding many other causal

⁵ See also the OECD Report from The First High Level Forum on Brain Mechanisms and Early Learning Report, Section 4. Mechanisms of Reading.

factors?⁶ The discussion turned to issues of group dynamics. Kids who are poor at reading pull back from a group environment, the group dynamic does not help in what they are lacking as they need to focus individually on the task that is challenging for them.

Issues in intervention studies with neuropsychological cases



Margarete Delazer's, University of Innsbruck, Austria, work mainly concerns remediation of adults who have problems with calculation.

She differentiates between 3 types of knowledge:

- facts (fast retrieval/automatic activation);
- procedures (familiar tasks/routine) and;
- concepts (flexible and adaptive, allows to make inferences).

In the acquisition of arithmetic competence there is a shift from time-consuming procedures to fast retrieval. This shift is supported by conceptual and procedural knowledge. In an fMRI training study modifications of cerebral activation patterns related to learning arithmetic were assessed. Healthy subjects were trained on a set of complex multiplication for a week. In the following fMRI session, trained problems and untrained problems were compared. Significant differences in left hemispheric activation suggest that learning processes in arithmetic are predominantly supported by the left hemisphere. This evidence concludes that behavioural changes of training are reflected by changes in patterns of brain activation. Her next project is to compare "learning by remembering" vs. "learning by doing." Delazer stressed the need to differentiate between teaching and rehabilitation. Acquired numerical deficits after brain lesions may be highly specific.

Fact training

Typical patients are persons who want to go back to their job and so wish to improve their calculation deficit. The aim here is to shift from time consuming strategies to fast and effortless retrieval by using methods of repetition of problems, production tasks, immediate feedback and correct answers in cases of error. For this therapy the study used an association of colours related to the second digit of the result. The reason for

⁶ Socio-economic factors do of course play a role in the context education, however, brain research is not yet in a position to integrate their implications. This project will aim to bring these factors into the debate, notably in the area of emotions and learning environments.

this choice being due to the fact that the first digit is usually correct, and also because in German the second digit is reversed (e.g. 25 = five and twenty). The patient is not aware of the colour and digit association, but it was shown to make a marked improvement. Another study was done using sounds, the patients were not aware of the connection. Both studies using this kind of therapy with colour and sound effects had an implicit learning effect. Delazer warns never to start with fact training when concepts are missing, for example it makes no sense to repeat that 3×4 gives 12 when a patient has lost understanding that 3×4 is equivalent to $4 + 4 + 4$. One should always strive for errorless learning – especially for patients with memory problems.

Conceptual/strategic learning

Her strategic learning intervention is based on strategies and explicit reference to the principles underlying simple arithmetic, the aim being the integration of conceptual, procedural and declarative knowledge. In the end the amount of information to be memorised is reduced. The strategic learning study showed significant improvement in a short period of training. The flexible use of strategies indicated meaningful organisation of acquired or reactivated knowledge.

Drawback of computer programmes

Delazer outlined the problems of computer programmes as they are motivating for most patients, but for those who are computer shy it is not. There are also sometimes attention problems, visual or motor problems. The available teaching programmes are sometimes also too complex, too fast or too childish.

Issues in designing number interventions: What has been learned from the Number Worlds Program



Most of the activities in the Number Worlds program are in a game format and these activities are grouped into five separate “lands”, each having a different visual language to represent numbers. In Line Land, for example, numbers are represented as positions on a path or line.

Sharon Griffin, Clark University, USA

Sharon Griffin, Clark University, USA, co-author of the Number Worlds Program, began by giving a brief overview of the program. It is a research-based mathematics program for young children that spans four grade levels (PreK to Grade 2) and that focuses, primarily, on teaching number knowledge and number sense. Program development was motivated and guided by three big ideas from cognitive developmental research. The first was a model of the development of children’s number knowledge across the middle childhood years (from 4 to 10 years of age). The second was the realization that the “mental number line” conceptual structure that most children construct around the age of 5-6 years, which links their understanding of number to their understanding of

quantity, provides the basis for number sense and for successful learning of arithmetic in school. The third was the discovery that there are a substantial number of children, living in low-income communities in Canada and the U.S., who start school at age 6 without this conceptual structure in place. On a developmental test of number knowledge, these children performed about 1½ to 2 years below average, placing them at serious risk for school failure. The Number Worlds program was designed to teach the knowledge specified in this structure and, in upper levels of the program, to teach the higher-level understandings that are built on this foundation. It was also designed to provide a test for the theory on which it was based.

Griffin explained that most of the activities in the Number Worlds program are in a game format and these activities are grouped into five separate "lands", each having a different visual language to represent numbers. In Object Land, for example, numbers are represented as groups of objects. In Picture Land, numbers are represented as dot-set patterns or as numerals. In Line Land, numbers are represented as positions on a path or line. In Circle Land, numbers are represented in a cyclical format, as a point on a dial. To illustrate the program, Griffin said she selected a sequence of activities from Line Land because line representations provide the closest spatial analogues for the "mental number line" conceptual structure the program is attempting to teach.

In the kindergarten program, one of the core games used to teach this structure is the Number Line Game. The game board displays four numbered paths extending from 1 to 10 and the goal is to see who is the first to get to 10. Players have to roll the dice and they then get chips according to the number on the dice. They then have to count the objects they receive and lay them out on the line. Then the child moves the pawn along the line until it is resting on the last chip. The numeral on which they land is also visible at the end of each turn because the chips are transparent. Griffin pointed out that this game exposes children to many different representations of number and provides opportunities for them to see the ways they are equivalent. As children become used to the routine of the game, they are asked questions, like how many they hope to roll, who has the most or the least etc. A lot of communication and interaction is involved in these games. In follow-up games that are played on the same game board, children draw cards from a stack of +1, 0, -1 cards and they have to work out what they have to do. In an earlier version of the same basic game children use their bodies instead of a pawn to move along a large Step-by-Step number line that is placed on the floor.

A popular first grade game is the Neighbourhood Number Line Game. It consists of 10 blocks of houses extending from 1 to 100. When fully assembled, the game board is 15 feet long. In one version of this game, children deliver packages to houses in the neighbourhood and they have to work out where the package should be delivered. The teacher asks a lot of questions such as, is number 54 farther away than the last delivery or closer? What numbers will you pass when you are delivering there? This game gives a physical sense to number magnitudes by the distance of delivery. When several packages have been delivered, children are asked if they can figure out a more efficient way to deliver them (e.g. by sequencing the numbers ahead of time). They are then given an opportunity to try this strategy and see how much time it saves. In a challenge activity, they are told that the delivery boy earns \$2 for each delivery and they have to compute how much he earned altogether.

The game expands further by adding a helper with magic shoes who can leap over 10 houses in a single bound, giving children practice in counting by tens from any number in the 1 to 100

sequence. Another game that gives an added sense of the composition of numbers is a Peg Board Game in which children add quantities, in different colours, to record the amounts rolled on a die on each turn of the game. Children then compare their total amounts and discuss the different number combinations that yielded these amounts. In second grade they play games on boards (e.g. the Apartment Game; the Hotel Game) where blocks of ten are stacked vertically, and so they learn to navigate the base ten system, literally learning to hop up one whole level to add ten to any double-digit number.

Five instructional principles that underlie the Number Worlds program are:

1. Follow the natural developmental sequence
2. Embed verbal and symbolic (digital) representations in a spatial (analogical) context
3. Use a high ratio of problems/representations to strengthen understanding
4. Provide many opportunities for exploration and ownership
5. Provide many opportunities for talking about, as well as doing math

Lessons learned from designing and using the program are:

1. Games are motivating and fun but the trick is to ensure that the problems they pose focus kids' attention on the links between numbers and quantity.
2. Keep props simple (Adding colour and amusing decorations can distract kids from the major focus).
3. Ensure that analog representations on props are consistent with (a) properties of the number system (e.g. larger numbers are farther away, higher up, farther around than smaller numbers); (b) standard forms of these representations (e.g. in dial representations, zero is at the top); and (c) children's spontaneous development (e.g. use base 5 for dot-set displays for younger children and base 10 for older children).
4. Enlist children's fantasy when creating contexts, story-formats, and titles for games, without violating cultural values (e.g. no mention of war, robbers).
5. Encourage use of problem-solving strategies that are natural for children (e.g. counting on fingers) and allow children to abandon them when they are ready.
6. Encourage children to describe the quantity transactions they enact, both orally and, in Grades 1 and 2, in writing.

Discussion

Emile Servan-Schreiber asked about the effects of the program on children's academic learning and achievement. Griffin responded by describing the results of a longitudinal study, which followed three groups of children (a low-SES treatment group, a matched low-SES control group, and a middle-SES comparative group), from the beginning of kindergarten to the end of second grade. The treatment group received the Number Worlds program and the other groups received a variety of other mathematics programs. At the end of kindergarten, the treatment group (which had performed about two years below average at the start of the year) had caught up to the comparison group on tests of number knowledge. For the remaining two years, their performance was commensurate with or better than their more affluent peers on tests of number knowledge, on a computation test administered at the end of grade one and on a battery of transfer tests administered at the end of grade two. By contrast, the control group fell further and further behind with performance that was below average on all measures.

Stanislas Dehaene asked if we needed to have the 250 different activities to teach number sense (as in the Number Worlds program) or if a few basic activities, that focus on core aspects of

number sense, will serve the same purpose. Griffin said that the number line software he is developing appears to target essential components of number sense and this may take him a long way in teaching it. Keiko Momii, a Japanese OECD staff member present at this symposium, said she thinks it is the abacus that makes the difference. Instead of dice and chips you have this didactic tool where you add digits to the left, and this gives the learners a very concrete visual sense for numbers. There has been no research across culture exchange to see if, for example, the use of the abacus in the Asian system is better. Griffin mentioned other cultural differences that might also influence math achievement. The first is language which might help Japanese children link numbers to quantify at an earlier age; they supposedly use numbers as adjectives to refer to the object, e.g., “I have three chairs” as opposed to “I have three”. The second is the way math is taught. In the West, we start with formal rules and then give students practice using them whereas the Japanese start with a concrete problem and ask students to generate a rule to explain it.

Outline of the proposed software for rehabilitation of core number knowledge



Our idea is to use the entertaining context of the computer game to get kids to develop a concept of an ‘internal mental number line.’

Anna Wilson, INSERM, Orsay

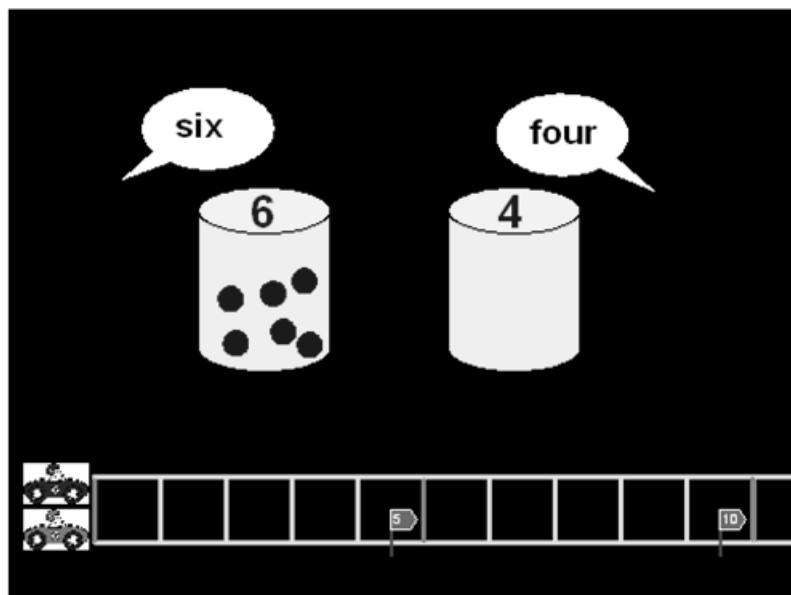
Anna Wilson, a New Zealander currently working as a post-doc at INSERM in France, presented the remedial software for developmental dyscalculia that is being developed by INSERM in collaboration with OECD for the Brain Research and Learning Sciences project website. Their overall goals are to design adaptive-game software to enhance children’s “number sense”. To this end they will adapt tests for dyscalculia and dyscalculia sub-types. They will carry out a pilot study testing the effectiveness of game software for remediation of dyscalculia co-occurring with dyslexia vs. pure dyscalculia.

The four main instructional principles of this software are:

1. Provide extensive numerical comparison practice, in order to increase precision and of reliance on quantity representation.
2. Cement links between magnitude, verbal and Arabic number codes
3. Emphasize link between numbers and space
4. Emphasize counting for calibration of quantity representation.

The reason that they chose computer remediation is because “adaptive game” interventions training phonemic distinction has shown to be highly successful with dyslexia. (e.g. Merzenich et al., 1996). Computers are motivating and entertaining for intense training on a positive task. It is easy to engage attention on a computer and they can give positive feedback. Lastly, computer interventions can be designed for use with minimum adult supervision.

Wilson then demonstrated a proposed software interface for this intervention with a number line representation on the screen. As it is difficult to fit a long number line on the screen, a zoomable number line with 60 seeming to be maximum is envisaged. The number line moves along with cars, dots and little animations. Added sounds, such as “applause” are envisaged.



Example screen from the core number knowledge programme

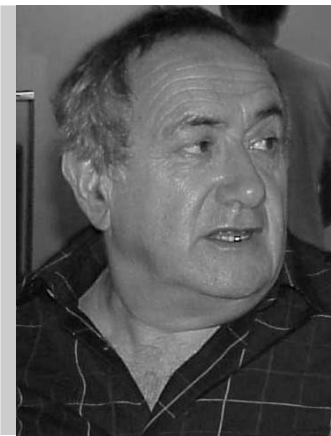
As the programme is worked through, eventually the verbal scaffolding is removed, so that there is just the Arabic digit representation, with increased numerical magnitudes, and decreased numerical distance between the numbers, as well as the inclusion of operations like addition and subtraction. The adaptive game will therefore have different difficulty dimensions of distance, magnitude, notation and operation. Hazards to add a level of complexity are included on the board, for example a negative “-2 shark”.

Discussion

The group expressed reservations about the software not being interactive. Bruce McCandliss mentioned a programme developed by Dan Schwartz where the user actually “teaches the agent” which could help to make the programme more interactive. Diana Laurillard suggested a networked game where learners compete and then can verbalize afterwards and talk about the mathematics. As an alternative the group suggested that the programme could incorporate asking predictions on the screen to prompt interaction.

Wilson said that general standardized tests, to identify kids to partake in the study were needed and that they were considering options such as the Standardised French CE2 (test for primary school evaluation), the Woodcock-Johnson or KEY-MATH test.

Brian Butterworth: Assessment of dyscalculia and intervention studies in the UK



What they discovered was that kids with dyscalculia and dyslexia often had high IQs.

Brian Butterworth, Institute of Cognitive Neuroscience, UK

Brian Butterworth began by saying that there is a prevalence of maths disabilities, with an estimated 3.6% in the UK (LEWIS et al, 1994) and as much as 10% in Norway (OSTAD, 1998). There are lots of reasons for being bad at maths, but is there a dyscalculia phenotype? Is dyscalculia a congenital condition that is not the consequence of deficits on other “more basic” cognitive capacities? Recent research on human infants and other species suggests that there are number-specific innate capacities, which may have a specific neuroanatomical locus. Butterworth explained numerosity as a property of sets. Numerosity should be distinguished from other numerical concepts, such as ordinality (including knowing the sequence of number terms one, two ..., and that Tuesday comes after Monday) and measures (continuous quantities). In order to test for the possession of this concept, the DfES undertook a study using small groups aged 9 years from the London borough of Harrow. They were particularly interested to find out how dyscalculics felt about their daily maths lesson and to the emotional effect of this on their learning. They also wanted to see how dyscalculia related to other cognitive capacities, and how it related to dyslexia. The study was done on focus groups to avoid the situation where there would be a big person before a small person. What they discovered was that kids with dyscalculia and dyslexia often had high IQs. Dyscalculics also appeared to have a sense of ordinality and were able to read and write three digit numbers. So, Butterworth said that a public screener was necessary in order to detect maths disability. Dyscalculia should be systematically diagnosed, and there should be recognition of the diagnosis by schools, education authorities, educational psychologists, the government and parents. The UK government has published National Numeracy strategy guidelines on this. This study also concluded that maths disabilities were not a consequence of slow reading or reading disability. Maths disabilities were found to be due to a deficit in basic numerical abilities. Butterworth also gave examples from live recordings taken in the focus groups on what the dyscalculic children say about trying to cope cognitively in their maths class. One child went as far as admitting to feeling “stupid”.

Butterworth summed up the implications for practice intervention and support for children with maths disabilities: Individualised learning schemes can help so that the kids are taken out of humiliating experience in the classroom; methods are needed for helping

children with maths disabilities to grasp basic number concepts; practitioners know a lot about interventions, but they should see how this can be relevant to scientific research; e-learning as an intervention tool should be explored ,as children like computer games (however, games should focus on numerosities and not be number bond drills in a pretty disguise).

Towards a Unified e-Learning Strategy



E-learning can be completely transformational in cases with children with learning disabilities.

Diana Laurillard, Department for Education and Skills, UK

What is E-learning? Diana Laurillard began her presentation by explaining that e-learning encapsulates many things such as individualised learning, personalised support, collaborative learning, tools for innovation, online communities, and quality of learning on a large scale. She outlined the goals of e-learning today as being: to raise standards, improve quality, remove barriers to achievement, widen participation and prepare for employment. She stressed the need to take strategic actions to embed e-learning across all sectors. All learners have their unique learning styles, but some have learning difficulties. E-learning can individualise the support to the learner. Laurillard stated that e-learning can be completely transformational in cases with children with learning disabilities. “Diversity is represented in many ways within classrooms. All learners have their unique learning styles, but some have learning difficulties or face other barriers to learning and participation, such as dyslexia or dyscalculia. Embedding individualised e-learning can help to remove barriers to learning and participation, meet individual needs and support all learners in reaching high standards.”

Pupils have made significant progress in reading, some as much as 10 months, with the support of e-learning tools. She cited the example of the Lexia Reading system which has proved a success for older pupils because of its structured, comprehensive phonics programme with interactive exercises which encourage pupils to work independently and at their own pace: “Children who suffer from attention and concentration problems in the classroom, often find it easier to concentrate and focus their attention on a computer screen.” (Advisory Support Teacher). Another case study example is The English Online course at the Sheffield College which achieved a 100% pass rate and 55% with A or A* compared with the national averages of 59% and 13%, respectively. Among the 41 students who completed the course were two excluded from schools, a 47- year old who felt let down by formal education and who was diagnosed as dyslexic, and several learners from outside the region who could not get the education they needed locally. Personalised programmes have also been seen to help children with speech deficits. Collaborative, social learning in interactive games on the internet can be brought into the

classroom. Virtual learning can take learners beyond the classroom environment, and out into the practise of skills.

Laurillard stated that it is important to remember that e-learning starts with the learner and their individual learning needs. We have a generation of teachers who have not been brought up with e-learning. The teachers themselves also need to be supported in pedagogic innovation through training and career motivation, peer support, etc. People do not yet know how to evaluate e-learning, and guidance for e-learning is needed for each discipline, as well as for support staff. With professional development, the large body of the teaching workforce need ongoing professional development. The priority in this strategy for e-learning is leadership, as it is education leaders who need to understand the value and implementation of e-learning in order for an organisation plan to materialise. Generic e-learning design tools for learners and teachers need to be developed. Teachers need an authoring environment for using the software in their lessons in order to be able to make sequences which they can try out, readjust accordingly and ultimately share with others. One of the most important aspects of innovation in e-learning will be to focus on learners with special needs, for example, developing interactive diagnostic tests and remediation for dyslexia and dyscalculia. To conclude Laurillard stated that we need to find out how we can persuade funding bodies to focus on learners with special needs, and how to collaborate to develop interactive diagnostic tests and remediation.

OECD Website and Next Steps

Emile Servan-Schreiber presented the project website, which is hosted on the main OECD portal.

He identified core target groups for the website:

- Educators, Policymakers: At this stage, to propose new ways of thinking about education and learning from the perspective of cognitive neuroscience (including debunking neuromyths). Later, to prescribe practical applications of brain and learning sciences into the classrooms (including teacher training), and other areas of public policy.
- Parents: To debunk neuromyths related to early learning, to increase awareness of the timeline of a young brain's development, and to point to efficient remedial programmes for learning difficulties such as dyslexia.
- Individual Brain Owners: To promote a better understanding of, and possible ways to enhance or maintain, one's learning abilities throughout life.
- Journalists: To highlight the unprecedented nature of this ground-breaking project, both in terms of the brain power involved around the world, and the ambition of its programme.

Both the Literacy and Numeracy networks are planning specific web-based intervention programs for some forms of dyslexia and dyscalculia. This meeting has thus been instrumental in putting this plan into action by way of exchange on ideas between programmes for dyslexia vs. dyscalculia, of methodology, what has already been successful, the pros and cons of computer programmes, ideas for props and scaffolding etc. Our website plans to make these programs available at large, for free sometime in 2004.

The next steps in this area of work are to have a meeting on dyscalculia and its subtypes and one on what works and what does not work. This meeting will be held as a joint meeting with the literacy and numeracy networks and is scheduled from 1-3 March in Madrid, Spain. .

Conclusions

The conclusions that can be drawn from this mini-symposium are that when designing a remedial programme for dyscalculia, the focus should be on specifically strengthening the neuronal structures and pathways identified by the triple-code model and the pre-existing "proto-number line". To this end, the various metaphors of ladders, rows of houses, or racing circuits to represent number lines and quantities, and even the ancient Abacus, are relevant. These can all help the designer to come up with innovative scaffolding features so as to engage the learner. However, the drawbacks of computer flashy gimmicks are that they could distract the learner, so this should be born in mind. At the end of the day, the aim is to create a software programme that will give the child a clear model for a number line with which to train his own "internal" number line, to make it internationally and culturally friendly, freely available to all by way of the OECD website on a common platform, and to eventually diffuse the results online.