The NumberTalk project:

How are children with language difficulties doing in Maths, and what factors are associated with success?

Chris Donlan, UCL, Richard Cowan, Institute of Education

How do children with language difficulties get on with Maths? Are there some areas of maths that are easier to learn than others, when language is restricted? What makes the difference between success and failure? And how does the National Numeracy Strategy fit the needs of children with language problems?

These are some of the ambitious questions recently addressed by the NumberTalk project.

As a start point, we looked at different sorts of mathematical skills. Let's take some common examples from everyday life.

1. Working in a Café

Just imagine you're helping with refreshments at the Summer Fair. There's no till and no calculator, just a price list (below) and a long queue!

Tea 50p	Cake 50p
Coffee 75p	Baguette £2
Squash 10p	(goat's cheese 20p extra)
Biscuits 15p	

The next customer is making their order. "Two teas and a coffee, a squash, three biscuits, no, umm, four biscuits and I'll have a goat's cheese baguette!"

How much does all that come to? Imagine you're pouring the drinks and getting the food at the same time. Doing all this and producing the right price requires ***Efficient Number Processing***! To give the right change as well is Super Efficient!

Many skills are involved here. You have to manage numbers in three different forms (written numbers, spoken numbers and coins), you have to perform calculations (probably using 'facts' you already know, like two 50s make a hundred) and very importantly you have to keep track of where you're up to and what comes next, as well as checking that the tea is the right strength and the coffee is hot enough. These simultaneous mental demands can cause an overload in Working Memory! And if we get anxious about it, then things get even worse!

2. Checking Figures

Suppose you've given a questionnaire to your company's customers and you're reporting the responses. You put the numbers in a Table (below), including the percentages for each type of response. Now check through the Table. Do the figures make sense? If there's a mistake, where is it and how would you put it right?

Response	Number	Percentage
Furious	188	9%
Unhappy	104	5%
Content	122	13%
Happy	259	6%
Delighted	1349	67%

If you notice straightaway that a couple of percentages don't fit with their numbers, then you've got good ***Awareness of Proportion***. If you also realise that swapping them round solves the problem, then you've got Super Awareness! This is a different sort of skill from the example above. Here we don't need to be absolutely precise. So long as we understand how percentages work we just need a sense of the value or magnitude of each number, and how it fits in order with its neighbours. This sense of proportion is really important in everyday life. It helps us to look at what numbers mean, and allows us to see if we're being misled!

3. Currency Exchange

I just learned that I've inherited some money from an uncle in the USA. After taxes and so on, I'll receive $34,340. Fantastic. I can buy that new shed I always wanted, and we can get a new car and..hold on! Just how much is that worth in pounds? The sterling exchange rate with the dollar was $1.717 last Autumn. How much is my inheritance worth in pounds…..?

These questions are a bit easier than they might look! If each $1.71 cents (or so) is worth a pound, then dividing the total dollars by $1.71 will tell you the number of pounds. So we're looking at 34,340 divided by 1.717. If you forget the decimals for a minute, something might strike you! Double 1717 is 3434! So double it and then sort out the decimal places. Now if you know roughly how dollars and pounds relate (proportion again!!), you can get the answer. £20,000 exactly! A shed and a small new car at least!

If all that left you a bit fazed, try the second question instead! The rate has been going up. It's now more like 1.81. Suppose I got this rate instead of 1.717. Would I get more or less sterling for my dollars?

If you know the answer to this without even working out the difference, then you understand the ***Principles of Division***, in particular, the greater the number you divide by, the smaller the result. Most of us need to work things out to get the answer, but a grasp of the principles will take you far!

These examples illustrate three key areas of maths. In the NumberTalk project we scaled down the difficulty level, and used tasks that fitted with National Numeracy targets, but still covered the three key areas: Number Processing, Awareness of Proportion and Understanding of Principles.

The project received tremendous support from head-teachers, teachers, speech and language therapists and, not least, children! Our researchers visited schools in the South of England, the South Midlands, and Wales. We recruited children with language difficulties from Language Units and some Special Schools. All the children had a Specific Language Impairment (SLI), i.e. their language test scores were significantly below their scores on a reasoning test with no language involved.

Our final sample contained 55 eight year old children with SLI, as well as two comparison groups of typically developing children from their schools, or ones with similar catchment areas, (55 eight year olds and 55 six year olds). All the children completed a range of tests covering language and maths, including the three areas outlined above. Comparing groups

allowed us to see how well the SLI group performed compared to levels expected for their age, or for their language level (which matched that of the six year old group). Let's look at the results in the three key areas.

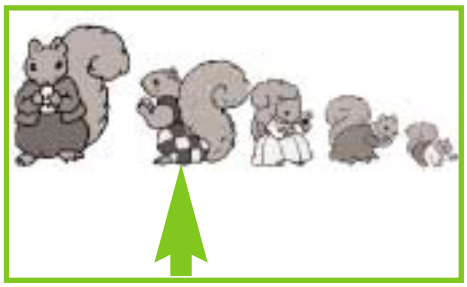
Number Processing

Here we tested children's ability to count aloud, to 'translate' between number formats (written/spoken /printed), to do simple sums, and to recall simple arithmetic 'facts' (e.g. to produce the answer to 4+3 in just a few seconds). In every task the SLI group performed more poorly than typical eight year olds; in counting aloud they were particularly poor, achieving no more than the six year old level. Of importance, though, is the fact that the range of performance in the SLI group was wide, so that some children with SLI performed as well as typical eight year olds throughout.

Awareness of Proportion

Choose which is bigger, 2018 or 2180? If you understand number values then tasks like this are easy; if the two numbers are on a computer screen, and you have only to press a key to show your choice, then language should not interfere with your responses. Or so we thought. In fact our SLI group were again substantially poorer than typical eight year olds, though better than six year olds. Once again the range in the SLI group was substantial, with a few individuals doing well.

Our second proportion task looked at children's ability to order pictures according to their size, without any numbers involved. We helped the child to place cards showing a 'family' of squirrels in size order, as below.



Then we showed them a card with the squirrels' gloves, one glove for each squirrel.

Then we pointed at one of the squirrels, and said 'This is Grandpa, show me his glove!"

This proved harder than we expected for our SLI group. We are confident they understood the instructions, but they made just as

many errors in finding the glove as the typical six year olds. Altogether then, we found that children with SLI had problems with number values, and with ordering according to size. Their general Awareness of Proportion was not much better than their Number Processing.

Understanding of Principles

The last of our three key areas was hardest to test. We wanted to see how well they understood how arithmetic works, not simply recall answers to sums they'd learned. We came up with the idea of using unfamiliar numbers, and pretended that we had some maths homework done by children on Mars, using Martian numbers (we used Greek symbols for this!). Some of the homework had already been marked, and we asked the children to use this to help them to mark the rest. Here's an example:

$$\Pi + \varsigma = \delta$$

This sum is right, the teacher ticked it.

$$\varsigma + \Pi = \delta$$

So is this one right or not? You mark it! Many adults have to think very hard about this! It was certainly a demanding test. We used several examples of three sorts of sum, to be sure they were consistent. In this task our SLI group was closer to typical eight year olds than in any other task. As a group they were far superior to the six year olds.

Our findings showed that the SLI group were more like other children their age in Understanding Principles than either Number Processing or Awareness of Proportion. But there was also a lot of variation within each task. So we looked within the SLI group to see which underlying skills were most important for success.

Within the SLI group two factors proved to be most important. The first was counting skill. Children who counted well were generally successful in maths tasks. The second was Working Memory; children who could hold information in mind and work on that information at the same time were more likely to be successful.

Then we looked at the high performers. Twelve of our children with SLI performed as well as the majority of eight year olds across the range of Number Processing and Proportion tasks. The key factors distinguishing these from the rest were, once again, Working Memory and Counting skills. But while these factors were important, they didn't fully account for the pattern of success.

Looking for further clues we turned to the data the children's teachers provided about curriculum coverage. Might it be that children who had received more advanced coverage in the year prior to our testing were the ones who scored highest? Some of the high performing children with SLI had covered many of the targets, but others had covered very few. The same was true of the poorest performers with SLI. So overall there was no relation between curriculum coverage and maths skills in the SLI group.

In discussion with experienced teachers we have found that many see benefits in the framework that the National Numeracy Strategy has to offer, but many also see a considerable risk for children who find the pace of learning too fast. Our finding that coverage of targets is not related to maths skills may arise from just such a problem. Our project did show that some of the best performers in the SLI group were children who had covered fewest topics in the classroom. It may just be that this had allowed them to develop really solid counting skills and mastery of number formats, and had helped them to build up and apply the critical resources in Working Memory that seem to underpin a broad range of mathematical learning.

We have found the NumberTalk project to be as exciting as it is has been demanding. We hope the findings will help children and families, teachers and therapists to focus on key skills, and to enjoy their learning! We look forward to hearing your comments.

NumberTalk was funded by the Nuffield Foundation, and conducted by Chris Donlan(UCL), Richard Cowan (IoE), Liz Newton (UCL), Delyth Lloyd (UCL)

Contact: c.donlan@ucl.ac.uk