//HEADLINE// **Beyond SEND - why diagnosis should not dictate intervention**
//BYLINE// Joni Holmes, Joe Bathelt and Duncan Astle - MRC Cognition & Brain Sciences Unit, University of Cambridge

Alfie is eight years old and he has a reputation in his primary school. His Reception, Year 1 and Year 2 teachers found his behaviour hard to manage: he wouldn't sit still, he often disrupted other children and he found it hard to pay attention.

Academically, he struggled too: he was making slower progress in reading than many of his peers.

So when he started Year 3, his new teacher - Sarah - decided something had to change. She discussed Alfie with his previous teachers and with the Special Education Needs Co-ordinator (SENCo) and she arranged a meeting with his parents. The latter proved pivotal: they told her Alfie's behaviour at home was the same as in the classroom. Sarah suggested a chat with the GP might be helpful.

Alfie was referred by his GP to Child and Adolescent Mental Health Services and was diagnosed with ADHD. Finally, the school and Alfie's parents had an answer, and the right support would follow, right?

Not necessarily.

Up to 15% of the school population are recognised as having special educational needs. But what do we actually know about why so many children find learning difficult?

We've been addressing this question through work in the Centre for Attention Learning and Memory (CALM) at the MRC Cognition and Brain Sciences Unit, University of Cambridge. And a recent study we published in the journal Developmental Science found evidence for something many who work in special schools have suspected all along: we rely far too heavily on diagnosis to support those with special educational needs (SEN) and that diagnosis rarely relates to the underlying reasons why a child is struggling.

What follows is a version of this recent paper that we have written exclusively for the Tes teacher audience.

<Part One: Following the diagnosis>
It is not just Alfie who has a diagnosis of ADHD in Sarah's class. She has two other pupils with the same diagnosis, and all three take methylphenidate (Ritalin). The three children, however, are very different in their behaviour and attainment in school. Alfie, as we know, is struggling with both behaviour and attainment. One of the other children is making good progress with few behaviour issues. The third child is struggling academically but her behaviour is not as disruptive as Alfie's – she can often be found daydreaming or looking out of the window rather than paying attention to the task at hand.

Then there are other children in Sarah's class with different challenges. There is Jessie, who is 7. Her reading level is that of a child almost three years younger. Following discussions

between the SENCo and Jessie's family, the school organised an assessment with an educational psychologist. The educational psychologist report said that Jessie has dyslexia. It provided Sarah with some teaching strategies and materials that she could use in the classroom with Jessie. The report is being used to obtain and an Education, Health and Care Plan to provide additional support for Jessie at school, but it has not come through yet. Sarah has a teaching assistant who spends half a day a week providing additional support to Jessie in the classroom, guided by the materials provided by the educational psychologist.

Finally, there is Ella, who is also 7. Sarah has noticed that her reading is poor and that it is impacting on other aspects of her learning. Ella does not have a diagnosis, but Sarah has liaised with the school SENCo who has initiated School Action in line with the SEN Code of Practice. She is waiting for the first meeting to decide whether Ella has SEN and what action might follow to support her needs. At the moment Ella receives no additional support at school.

Despite all three children displaying similarly low levels of reading, Sarah is being guided by the labels given to the children and recommended approaches for intervention (medication for ADHD; one-to-one TA support for dyslexia; School Action for SEN).

This should work. Their reading skills should improve. Shouldn't they?

<Part Two**. What do learning difficulties really look like?>**

Learning difficulties and associated developmental problems do not fall in to tightly-defined categories. Symptoms often co-occur across diagnoses, and two children with the same diagnosis can also look very different.

For example, it is not uncommon for a child with ADHD and another with dyslexia to both have problems sustaining attention during challenging tasks. Similarly, no two children with ADHD will look the same: some are more hyperactive and defiant, while others are less disruptive and more inattentive.

Stepping back from diagnoses, we also see that classroom learning difficulties rarely occur in isolation. There are high rates of comorbidity between reading, maths and language problems, with some estimates reaching up to 50%. This is not to mention strong overlaps with mental health – according to the Royal College of Psychiatrists up to 40% of people with learning problems experience mental health difficulties.

In practice, many teachers and educational professionals recognise the complex needs of children who are struggling at school. Some leading special schools have stressed the need to move away from labels and instead focus on the individual child and their needs, using diagnostics as supplementary information when needed (https://www.tes.com/news/tes-magazine/tes-magazine/ditch-send-labels-and-focus-individuals). A similar move has been advocated for many years in developmental science. But to date very few studies have adopted such an approach.

<Part Three: Studying struggling learners - making no assumptions>

The record of research informing educational practice is patchy. The use of phonics to teach reading is great example of how scientific evidence has fed through to everyday classroom practice. But our understanding of learning-related difficulties, and how to support them, is dominated by studies of children with either very specific profiles of learning problems (e.g. reading difficulties in the absence of maths problems or low IQ), or of children with particular diagnoses in the absence of co-occurring problems or diagnoses.

This approach makes lots of assumptions about struggling learners that practitioners know may not be valid – learning difficulties are rarely specific, behavioural problems rarely occur in isolation, and most children who struggle will never receive any diagnosis.

A similar issue was recognised in the field of psychiatric disorders and adult mental health a few years ago. Here, scientists realised that the majority of studies failed to capture high levels of co-occurrence between anxiety and depression, differences in symptoms for individuals diagnosed with the same condition, or similarities in symptoms across diagnoses.

This prompted the adoption of what has since become known as a 'transdiagnostic approach' – that is identifying the causes of particular groups of symptoms, irrespective of diagnosis. This approach makes no assumptions about why someone might be struggling based on previous information, such as a diagnostic label.

This is what we need more of when it comes to struggling learners.

<Part **4. The study - What we did and why>**
We wanted to conduct a truly "transdiagnostic" study of children who struggle in school. Our main challenge was collecting data from a large sample of children who were recognised as having learning-related problems, irrespective of any labels they may or may not have. The key to our success would be whether we could recruit a deliberately broad sample of struggling learners. Our colleague Professor Susan Gathercole OBE FBA pitched the idea of opening a 'research clinic': we would take referrals from practitioners for children who appeared to be struggling. It was an ambitious idea, but it proved pivotal.

We asked health and educational professionals (SENCos, speech and language therapists, specialist teachers, psychologists, psychiatrists and paediatricians) to refer children aged 5 to 18 to the CALM research clinic. Formal diagnoses were not required and no exclusions were made on the basis of co-morbid psychiatric, psychological or physical health conditions. We accepted children in to the study with none, one or multiple diagnoses. As long as someone with expertise in recognising a cognitive-related learning problem said they were struggling, we took them in to the study.

Initially we did not know whether anyone would refer children to us, but we should not have worried. To date we have seen nearly 800 children. Here we are telling you about the results of a particular analysis we ran on the first 550 children seen in the clinic.

All children completed a broad set of assessments of cognitive abilities known to be impaired in children with learning difficulties. These included tests of vocabulary, sound processing (phonological processing), memory, problem-solving (executive function and IQ) and attention. They also completed assessments of maths and literacy skills.

Children were offered an optional MRI brain scan, and parents / carers completed multiple questionnaires about family history and the child's behaviour, mental health and communication skills.

The breadth of the recruitment criteria, the scale of the study and the multiple levels of assessment make this study a unique resource for understanding why some children struggle at school.

There are so many interesting questions that you can ask of a dataset like this – and within CALM many researchers are working to make the most of this resource.

The analysis approach we used in this study was machine learning. Our aim was to understand more about the sample of struggling learners we had recruited, and in particular how their cognitive difficulties related to the particular reasons for referral, their diagnoses and their learning profiles.

It sounds fancy, but really it isn't. Machine learning is a branch of computer science related to artificial intelligence that we use every day without knowing it. Each time you type a word into an internet search engine a machine learning algorithm learns about your interests and preferences. It is trying to learn the structure of the input you provide – that is, it is trying to learn the consistent patterns. The machine learning creates a model of your preferences and interests, based upon your search history, which is then used to suggest things you might like.

We used a class of machine learning called an 'artificial neural network'. These have been popular in lots of other areas of science; it's been used to learn about weather systems, economic patterns, seismic activity and ocean currents. When you don't know the structure of your data – like a new search engine that has no prior knowledge of its user – machine learning is powerful way of learning that structure.

So having collected information from hundreds of struggling learners we used the algorithm to learn about the consistent patterns in the data. We fed the artificial neural network information about children's vocabulary, listening skills, various types of memory and reasoning ability.

What would the algorithm learn about the structure of this input?

<Part Five: **Can it distinguish apples and oranges?>**
Imagine for a moment you knew nothing about fruit, and wanted to use machine learning to help you.

First, you would have to define some sensible ways in which fruit could differ from one another – their diameter, their colour, their acidity levels, their seed size, their juiciness, and so on.

Second, you would need to measure all these attributes in every fruit.

Third, you would have to introduce these values to the machine learning.

As the fruit are introduced, the algorithm gradually sorts them according to these attributes. Our version of machine learning represents what it has learnt as a map. The more similar the fruits, the closer they sit in the map. For example, lemons and limes will sit alongside each other, because they are very similar. By contrast, bananas would be represented somewhere else in the map, because they have very little in common.

So what did our map look like in this study?

Our machine learning learnt about the cognitive profiles that existed in our sample. It learnt that many children had consistently poor scores on all our assessments, some children struggled with tasks that involved working memory, some children were really poor at any tasks that relied on verbal skills, and a sizeable portion of the sample had no cognitive difficulties at all (to our surprise).

We predicted that children with, say, ADHD would sit together in the map. After all, they have the same diagnosis, so they must be very similar to each other. But that was not the case. For example, a child with an ADHD diagnosis was equally likely to sit anywhere within the map, indicating that the diagnosis did not correspond to their cognitive profile. In fact the same was true of other diagnoses that were represented within the clinic, like dyslexia or autism spectrum disorders (ASD).

In short, the machine learning mapped the profiles of children who struggle at school. These profiles were strongly linked to their academic performance, language abilities and brain structure. But they were not strongly linked to any diagnoses the children came with.

Now, this is not to say that these diagnoses are not still important. A diagnoses is a landmark moment for children and families, and should lever additional support for that child. But when providing practical support it is important to keep in mind that diagnosis does not correspond closely with the child's underlying cognitive difficulty.

Another key point from this study is that most struggling learners we saw did not have a diagnosis of any kind: having a diagnostic label was not a good predictor of whether a child would struggle or not, let alone why they might struggle.

The machine learning also taught us something else that we had not expected: children can have similar profiles of learning, but for different underlying reasons. In our data two children in a class could both have moderate learning problems in both reading and maths, but with different underlying roots. One might have underlying problems in verbal skills or phonological processing, while the other might be struggling due to problems with working memory.

This presents a real challenge to practitioners because the two children will present similarly in class, but the underlying cognitive origins of those difficulties could be somewhat different.

<PART SIX: SO WHAT DO WE DO NOW?>
We would recommend the following based on our findings:

- **We need better, easier and cheaper assessments**
- When we speak at practitioner conferences a common question is where professionals can get their hands on cognitive assessments. Despite being incredibly simple, most are prohibitively expensive. That needs to change.
- **Better funded SEN provision**
- Most schools we worked with could not afford to get support from the educational psychologist. Indeed, we suspect that one reason recruitment was so successful was because our study provided the only means of professionals getting access to this kind of cognitive data on the children. Tailored help for children requires that they have support from educational psychology services. In our experience, this has become impossible for most schools.
- **SENCo and teacher training**
- Knowing the ways in which cognitive profiles can differ, and how they correspond to learning could be really useful information for teachers. For example, many of our struggling learners had working memory problems. Reducing working memory demands in the classroom with different tricks and strategies can significantly improve learning outcomes for children with poor working memory capacity. Integrating this within teacher and SENCo training would be valuable.

Concluding remarks

Our study is the first to map cognitive profiles in broad group of struggling learners. It clearly demonstrates that diagnoses do not map on to cognitive skills.

These findings underscore the need to understand more about why children are struggling in the classroom, rather than simply adopting off-the-shelf interventions for particular labels.

The key message is that children with the same diagnoses do not necessarily have the same underlying cognitive problems. What works for one child with a diagnosis might not work for another child with the same diagnosis.

We adopted one method of analysis – machine learning – but there are many others available that may provide additional or complementary information. We believe the challenge moving forward is to develop ways to chart profiles across learning, cognition, behaviour, the brain and genes. This way we will gain richer information linking particular profiles of learning-related problems to (potentially different) underlying causes. As we push our understanding of what different mechanisms can give rise to difficulties in learning, we can better target our interventions.

Finally, it is crucial to map changes in cognition and learning over time to identify risk and resilience factors for persistent learning difficulties. We are about to start a five year follow-up of the children referred to CALM to do just this. Watch this space.

Dr Joni Holmes is the Head of the Centre for Attention, Learning and Memory at the MRC Cognition & Brain Sciences Unit, University of Cambridge and a Fellow of Wolfson College, University of Cambridge. She has a PhD in Psychology and held numerous research and lectureship posts in Leeds, York and Newcastle before moving to Cambridge as a senior scientist in 2011. Joni's research focuses on the causes and remediation of specific learning difficulties. She has been running the Centre for Attention, Learning and Memory (CALM) since 2014. Research conducted in CALM aims to illuminate the cognitive, neural and genetic underpinnings of learning difficulties. The clinic provides free resources for professionals supporting struggling learners: http://calm.mrc-cbu.cam.ac.uk/useful-resources/. Joni is an editor at Memory and the Journal of Experimental Child Psychology. Her work has been supported by the Medical Research Council, the Economic and Social Research Council, The British Academy, The Baily Thomas Charitable Fund and Action Medical Research.

Dr Duncan Astle is a Programme Leader at the Medical Research Council's Cognition and Brain Sciences Unit, and a Fellow of Robinson College, University of Cambridge. Prior to this he completed his training at Durham and Nottingham, and held fellowships at Oxford, Royal Holloway and Cambridge. His research uses multiple methods to explore how brain systems develop through childhood, in typically developing children, children with disorders of attention, children with genetic mutations, and children with problems in classroom learning. His work has been supported by the Royal Society, the British Academy, the Medical Research Council, the Economic and Social Research Council and various charitable foundations. Duncan currently serves as SAB Chair of the Cambrige NIHR BioResource, is an Editor at the Journal of Neuropsychology and in 2017 Duncan was awarded the Early Career Prize by the British Association of Cognition Neuroscience in recognition of his outstanding contribution to the field.

Dr Joe Bathelt is a post-doctoral researcher at the MRC Cognition and Brain Sciences Unit, University of Cambridge. Before coming to Cambridge, he completed his PhD in Developmental Cognitive Neuroscience at the UCL Great Ormond Street Institute of Child Health. His research investigates differences in the cognitive development of children with sensory, genetic, or learning disorders using a combination of brain imaging, behavioural assessment, and advanced statistical methods. His research has been supported by the Medical Research Council, University College London, Great Ormond Street Hospital Children's Charity, and the Royal National Institute of Blind People.

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