The CALM study: outcomes and practical implications
The CALM approach

- Transdiagnostic
- A focus on:
  - those children who practitioners consider to be facing functional challenges
  - the individual child and not their diagnoses
- Common, complex and co-occurring
- Inclusive
- Asks: What are the barriers to positive outcomes for the individual child and how can they be overcome?
CALM Partnerships

- SENCOs
- Head teachers
- Specialist teachers
- Educational psychologists
- Clinical psychologists
- Occupational therapists
- CAMHS
- Paediatricians
- Speech and language therapists
The CALM study in brief

Wave 1
i) 805 children aged 5-16 with reported difficulties relating to attention, learning and/or memory
   ▶ Practitioner identified: education (63%), CAMHS & paediatrics (33%) and SLTs (4%)
   ▶ 40% reported receiving diagnoses (26 different, often co-occurring), most frequently ADHD (approx. 30%), dyslexia & ASD

ii) 200 comparison group

Wave 2 (mean + 4.8 years)
302 children re-assessed
## Diagnoses

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>N (female)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADD</td>
<td>14 (8)</td>
</tr>
<tr>
<td>ADHD</td>
<td>183 (40)</td>
</tr>
<tr>
<td>ADHD under assessment</td>
<td>56 (16)</td>
</tr>
<tr>
<td>Hyperactivity</td>
<td>1 (0)</td>
</tr>
<tr>
<td>Dyslexia</td>
<td>47 (15)</td>
</tr>
<tr>
<td>Dyspraxia</td>
<td>21 (7)</td>
</tr>
<tr>
<td>Dysgraphia</td>
<td>1 (0)</td>
</tr>
<tr>
<td>Dyscalculia</td>
<td>2 (2)</td>
</tr>
<tr>
<td>FASD</td>
<td>6 (4)</td>
</tr>
<tr>
<td>Generalised/global delay</td>
<td>10 (5)</td>
</tr>
<tr>
<td>Depression</td>
<td>3 (3)</td>
</tr>
<tr>
<td>Anxiety (inc. social anxiety)</td>
<td>9 (4)</td>
</tr>
<tr>
<td>Autism</td>
<td>57 (7)</td>
</tr>
<tr>
<td>PDA</td>
<td>1 (1)</td>
</tr>
<tr>
<td>Tourettes</td>
<td>5 (1)</td>
</tr>
<tr>
<td>DAMP</td>
<td>4 (1)</td>
</tr>
<tr>
<td>OCD</td>
<td>5 (4)</td>
</tr>
<tr>
<td>Sensory processing disorder</td>
<td>3 (1)</td>
</tr>
<tr>
<td>Language disorder (inc. SLI)</td>
<td>2 (1)</td>
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<tr>
<td>Conduct disorder</td>
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<tr>
<td>ODD</td>
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<tr>
<td>Epilepsy</td>
<td>4 (2)</td>
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<tr>
<td>Anorexia</td>
<td>1 (1)</td>
</tr>
<tr>
<td>Speech &amp; language therapy</td>
<td>160 (51)</td>
</tr>
<tr>
<td><strong>No diagnosis</strong></td>
<td><strong>484 (165)</strong></td>
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## CALM assessments

<table>
<thead>
<tr>
<th>Cognition</th>
<th>Learning</th>
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</thead>
<tbody>
<tr>
<td>Attention</td>
<td></td>
</tr>
<tr>
<td>Episodic memory</td>
<td></td>
</tr>
<tr>
<td>Executive functions</td>
<td></td>
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<tr>
<td>Phonological processing</td>
<td></td>
</tr>
<tr>
<td>Processing speed</td>
<td></td>
</tr>
<tr>
<td>Nonverbal reasoning</td>
<td></td>
</tr>
<tr>
<td>Working memory</td>
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</table>

<table>
<thead>
<tr>
<th>Behaviour</th>
<th>Learning</th>
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</thead>
<tbody>
<tr>
<td>Executive functions, attention, social, communication</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Mental Health</th>
<th>Learning</th>
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<tbody>
<tr>
<td>Depression, anxiety, history</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Brain</th>
<th>Learning</th>
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</thead>
<tbody>
<tr>
<td>Structural MRI, diffusion-weighted imaging, resting-state</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Genes</th>
<th>Learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saliva</td>
<td></td>
</tr>
</tbody>
</table>
All made possible by

Duncan Astle
Kate Baker
Susan Gathercole
Joni Holmes
Rogier Kievit
Tom Manly

Jonathon Jones
Silvana Mareva
Jessica Martin
Elise Ng-Cordell
Sinead O’Brien
Clodhna O’Leary
Joseph Rennie
Andrea Santangelo
Ivan Simpson-Kent
Roma Siugzdaite
Tess Smith
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Jacakyn Guy
Erin Hawkins
Rebeca Ianov-Vitanov
Christian
Iordanov
Agnieszka
Jaroslawska
Sara Joeghan
Amy Johnson
.... and hundreds of children and practitioners
So, what have we learned about learning from CALM?
1. Learning and cognitive skills are below average in the CALM sample
2. Reading and maths achievements depend on different cognitive abilities

3. Behavioural difficulties are high across the sample.

Conners 3 Short Form (Parent Version)

- Peer Relations
- Aggression
- Executive Functions
- Learning Problems
- Hyperactivity & Impulsivity
- Inattention

Subscale

- Global Executive
- Metacognition
- Behaviour Regulation
- Monitor
- Organisation
- Planning
- Working Memory
- Initiate
- Emotional Control
- Shift
- Inhibit

Subscale

- 1 SD (<16%ile)
4. The majority of children with ADHD face complex challenges.

- 2/3 with ADHD have the same difficulties in learning and cognition as children in CALM without ADHD.
- But 1/3 have **neither** learning-related difficulties nor cognitive problems.
- Weak social communication skills accompany high levels of hyperactive and impulsive behaviour.

ATTENTIONAL BEHAVIOURS

INATTENTION

COGNITIVE SKILLS
Phonological
Spatial

LEARNING
Reading
Maths

HYPERACTIVITY/IMPULSIVITY

Social aspects of communication
Practical implications

- Understanding the breadth of challenges faced by an individual child is critical to effective support.

- Tailored approaches are necessary to capture the complexity of individual needs.

- Some individual challenges may require environmental modifications to optimize learning outcomes.
How best can these insights be put into practice to improve outcomes?
Do diagnoses capture the characteristics of the CALM sample?

Professor Joni Holmes
School of Psychology, University of East Anglia
The CALM Study: outcomes and practical implications, 17th June 2023

joni.holmes@uea.ac.uk
Supporting neurodivergent children

We aim to:

- identify unmet needs
- provide appropriate accommodations and support
Diagnostic approach

- Dyslexia
- ADHD
- Dyspraxia
- Autistic spectrum disorder
- Developmental language disorder
- Sensory processing disorder
- Dyscalculia
- Conduct disorder
Do diagnostic categories capture the characteristics of neurodivergent children?
Questions

Are different diagnoses associated with different cognitive profiles?

Do diagnoses align with children’s behavioural profiles?

Do diagnostic categories map on to parent reports of clinical features?

Do mental health conditions capture the characteristics of neurodivergent children?
Brief principles

Range of statistical methods to:

- identify groups of children in the sample with similar profiles across a range of cognitive or behavioural measures
- and test whether these groupings align with diagnostic status
- **OR** identify how clinical or mental health characteristics group together
- and test whether these groupings align with the features of particular conditions
Diagnoses do not map on to cognitive profiles

Astle, Bathelt & Holmes, *Dev Sci*: 2019
Holmes, Bathelt & Astle, *TES*: 2019
Children with particular diagnoses appeared in all clusters.
Clinical features

- Pragmatic Communication
  - Peer: Peer Relations (Conners-3)
  - Coher: Coherence (CCC-2)
  - Inap.Init: Inappropriate Initiation (CCC-2)
  - Stere: Stereotyped Use (CCC-2)
  - Context: Use of Context (CCC-2)
  - Nonver: Nonverbal Communication (CCC-2)
  - Social: Social relations (CCC-2)
  - Interes: Interests (CCC-2)

- Hot EF/Affective responses
  - Hyp: Hyperactivity/Impulsivity (Conners-3)
  - Agg: Aggression (Conners-3)
  - Inhib: Inhibition (BRIEF)
  - Shift: Shifting (BRIEF)
  - Emot: Emotional control (BRIEF)
  - Monit: Monitoring (BRIEF)

- Structural Language & Learning
  - Learn: Learning (Conners-3)
  - Speech: Speech (CCC-2)
  - Synt: Syntax (CCC-2)
  - Seman: Semantics (CCC-2)

- Cold EF/Behavioural organisation
  - Inatt: Inattention (Conners-3)
  - EF: Executive Functions (Conners-3)
  - Init: Initiation (BRIEF)
  - WM: Working Memory (BRIEF)
  - Plan: Planning (BRIEF)
  - Org: Organisation (BRIEF)

Features did not group according to diagnostic boundaries

Mareva & Holmes, *BMC Ped*: 2019
Mareva ... & Holmes, *JCCP*: 2023
Neurodevelopmental and behavioural characteristics in models of mental health

- Broad Internalising
- Broad Externalising
- Specific Internalising
- Social “Maladjustment”
- Neurodevelopmental

Mental health models:
- GAD
- Panic
- Soc Phob
- Sep Anx
- OCD
- Dep
- Agg
- Cond Prob
- Pros
- Peer
- Inatt
- Exec Func
- Hyp/Imp
Diagnoses do not align with cognitive or behavioural profiles

Clinical features and mental health characteristics do not align with diagnostic boundaries

Supports tied to diagnoses might not address most impactful characteristics
If our goal is to identify and provide appropriate support and accommodations for unmet needs, and the CALM data show the diagnostic system is not capturing these needs appropriately...

How do you think we could / should do this?

What are the barriers and challenges?
Huge thanks to collaborators, team and funders

The CEE lab past and present:
- David Ruttenberg
- Louise Glanville
- Maria Vedechkina
- Sofia Carozza
- Cornelia Cai
- Zoe Thompson
- Kelly Tang
- Emma Jagasseur
- Heulwen Bonsals
- Silvana Mareva
- Sinead O’Brien
- Kira Williams
- Erica Bottacin
- Zoe Thompson
- Kelly Tang
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- Fanchea Daly
- Tina Emery
- Sara Joeghan
- Sally Butterfield

The CEE lab past and present:
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- Tom Manly
- Kate Baker
- Rogier Kievit
- Susan Gathercole

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- Francesca Woolgar
- Natalia Zdorovtsova
- Mengya Zhang

CEE Lab
www.joniholmeslab.com

CALM
calm.mrc-cbu.cam.ac.uk
What does someone’s brain tell us about their cognition?

Duncan Astle
Neuroimaging in CALM

Cortical surfaces (grey matter)

Structural connectivity (white matter)

Functional connectivity (metabolism)

So what did we learn?
Four things we learnt from the CALM neuroimaging data

1. Differences in grey matter not very important for children’s cognition or learning
Four things we learnt from the CALM neuroimaging data

2. Differences in the brain’s organisation a better predictor of cognition

Siugzdate et al. (2020) *Current Biology*
Four things we learnt from the CALM neuroimaging data

3. Differences in the connectivity of the frontal lobes related to executive function profiles

Bathelt et al. (2018) JAACAP
Four things we learnt from the CALM neuroimaging data

4. We can simulate brain development with mathematical models

\[ P(i,j) = D(i,j)^\eta \times K(i,j)^\gamma \]

Children’s brain organise by simple mathematical rules, with small amounts of variability in those rules shaping differences in brain organisation.

Akarca et al. (2021) Nature Communications
Where next?! Widening access to the data

https://portal.ide-cam.org.uk/overview/1158
Thank you!

- To all the children and families that took part, and their referrers
- To the team members that undertook the bulk of the scanning
- Amazing radiographers
- To the army of PhD students and research fellows who used (and continue to use) the data!
What have we learned from genetics?

Dr Kate Baker, Dr Andrea Santangelo and Dr Silvana Mareva
Human brain development
Genetic influences on brain development

Cell identity
Patterns and connections
Activity, flexibility and stability
Genetics, environment & brain development
Genetic differences & brain diversity

Chromosome differences

Copy number variants

Sequence variants

Rare variants: Sometimes high impact on protein and development

Common variants: Low impact on protein and development. Collectively important
Polygenic scores (PGS)

- Numerical summary of genome-wide load of common variants
- Associated with an aspect of health or development

- For example: ADHD, IQ scores, Mental health diagnoses
Are PGS calculated from previous GWAS relevant to behavioural variation within CALM?

- For example:
  - ADHD
  - IQ scores
  - Mental health diagnoses
Polygenic scores (PGS) &

Genome-wide SNP genotyping
Infinium GSA-24 v3 (Illumina)

615 samples
~40,000,000 SNP after imputation

Standard QC steps:
524 samples and 7,568,187 SNP

PGS calculation

Individual PRS

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<thead>
<tr>
<th>SNP</th>
<th>CHR</th>
<th>BP</th>
<th>A1</th>
<th>A2</th>
<th>OR</th>
<th>SE</th>
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<td>1.003</td>
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</tbody>
</table>
Polygenic scores (PGS) &

ADHD PGS

Hyperactivity / Impulsivity

Inattention

Verbal IQ

IQ PRS

Non-verbal IQ

Consistent PGS threshold
Co-vary age and gender
$R^2$, $p<0.008$
Polygenic scores (PGS) & ADHD

Hyperactivity / Impulsivity
Inattention
Verbal IQ
Non-verbal IQ

ADHD PGS
IQ PRS

Consistent PGS threshold
Co-vary age and gender
Co-vary IMD
p<0.008
Polygenic scores (PGS) & Calm


N=218 with all measures
Consistent PGS threshold
Co-vary age and gender
Polygenic scores (PGS) & CALM

PGS calculated from previous GWAS are relevant to behavioural variation within CALM! How and why?

- For example: ADHD
- IQ scores
- Mental health diagnoses
Genetics, brains, cognition & behavior?
Acknowledgements

- CALM participants and families
- CALM team
- Andrea Santangelo, Diandra Brkic
- DNA extraction and storage – Sadaf Farooqi
- Genotyping – Lars Bertram, Olena Ohlei, Lifebrain consortium
- Funding – MRC, EU Horizon 2020, Isaac Newton Trust

Questions and suggestions?
Teaching and learning about neurodiversity to support inclusion in a school
An introduction to LEANS

LEANS Research and Impact Lead: Dr Alyssa M. Alcorn
Visiting Fellow at MRC-CBU, Summer 2023
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Alyssa.Alcorn@mrc-cbu.cam.ac.uk

LEANS
Learning About Neurodiversity at School

THE UNIVERSITY of EDINBURGH

#LEANSproject
CALM, June 17th 2023
Preface: LEANS and CALM

• LEANS is not part of, or affiliated with, CALM.
• This project/my work is **applied**, interested in changing educational practice and schools in short term.
• As an applied researcher, I think **basic science** like CALM is really important!
  • Some aspects of CALM will take a long time, have many intermediate steps before there are findings that directly apply in practice.
  • Some “big picture” findings we can use now, or use to **back up** what practitioners have learned from their practice—like that a diagnosis may not be a helpful explanation of an individual’s needs, or that children with different diagnoses may have very similar profiles.
The LEANS research team:
Dr Alyssa Alcorn, Dr Sarah McGeown, Dr Dinah Aitken, Fergus Murray, Prof. William Mandy, Liam J. J. Peacock, Reesha Zahir, Rebekah Smikle, and Prof. Sue Fletcher-Watson [PI]

The LEANS educator participatory design team:
Amy Nic Thaidhg, Chris Rigby, Erin Marie Tschiderer, Fiona McBryde, Joan McDonald (Posautive), Kate Bradley, Kirsten Duncan, and Sarah Douglas

LEANS illustrator: Claire Hubbard
Administrator: Susan Davidson
Webmaster: Emma Wilson

https://salvesen-research.ed.ac.uk/leans
Today is an overview, but there is more LEANS info online!

- The **LEANS website** is the best place to find more information!
  - Summaries and examples
  - Recorded talks, articles
  - Download the resources [https://www.ed.ac.uk/salvesen-research/leans](https://www.ed.ac.uk/salvesen-research/leans)

- **Add yourself to our mailing list** to get project news
  [https://edinburgh.eu.qualtrics.com/jfe/form/SV_0PLduvb6qRjSQNE](https://edinburgh.eu.qualtrics.com/jfe/form/SV_0PLduvb6qRjSQNE)
Introducing LEANS

• LEANS is a new resource pack to introduce neurodiversity concepts to mainstream primary classes in an accessible and engaging way.
• **Free, off-the-shelf, available right now** (download)
• Designed for ages **8-11 years**
• A **whole-class, teacher-delivered** programme
• Links to existing curriculum topics and priorities
  • Inclusion, diversity
  • Wellbeing, health, safety
  • Citizenship, human rights, and more!
Defining neurodiversity in LEANS

Children see the following definition:

“Neurodiversity means that we are all different in how we think, feel, and learn, because our brains process information differently. Neurodiversity includes everyone, because everyone has a brain!”

- Link to other types of human diversity (culture, language...)
- Stresses there is no one “right” way to be
Knowledge and attitudes matter!

• Research evidence for (comparably) poor neurodivergent outcomes
• Also evidence that poor factual understanding, stigma contribute can contribute to, compound other challenges.

Good news!
• Research *also* indicates that we can **address stigma** by increasing people’s knowledge.
• Has been shown specifically in schools, even over a short period.
• Tackling knowledge, attitudes can be cost-effective and scalable
LEANS goals: Positive changes at school

Post-participation in LEANS, we want pupils and teachers to...

- **KNOW:** To increase their **knowledge** of neurodiversity terms and concepts.

- **THINK:** To create more positive **attitudes** towards neurodiversity and neurodivergence.

- **DO:** To increase individuals’ positive and inclusive **actions** within the school community.
Resources are grouped into topic units

1. Introducing neurodiversity
2. Classroom experiences
3. Communication
4. Needs and wants
5. Fairness
6. Friendships and relationships
7. Reflecting on our actions

Mixture of materials: activities, discussions, stories about a neurodiverse class
Facts for teachers

• You *don’t* need to already be a neurodiversity expert to deliver LEANS!
• NO required training courses: Teacher Handbook is a “course in a book”
• Time requirement: 1-2 hours/week over 1 school term
  • Estimated 15-19 hours total to deliver the content
  • Longer delivery possible, shorter delivery tricky!
• LEANS is free, but needs a time investment.
Developing LEANS: How did we get here?

• Funding for an open brief
• **Participatory design process** with neurodiverse, experienced group of educators (professional + lived experience)
• Lots of **decisions** for team to make!
  • What does “teaching about neurodiversity” mean for this age group?
  • What type of materials to make?
  • What guidance do teachers need?
• Later consultation stages with additional teachers, community members.
4 primary schools in Scotland (2 small rural, 2 larger urban)

August-December 2021—In-person teaching with ongoing Covid disruption!

Evaluation goals: “Did it work?”

• Was LEANS acceptable, feasible, and safe when teachers delivered it in a real classroom?
• Did participation in LEANS affect children’s knowledge and attitudes? (impact)
What we did

• Teachers delivered LEANS in 8 classes across 4 mainstream primaries
  • About 140 children completed LEANS (1 class withdrew)
  • 62 children had opt-in parental consent to share quiz data with researchers (average age 9.8 years)
• Children completed quizzes before and after LEANS
  • Attitudes and actions
  • Neurodiversity knowledge
• Additional qualitative data from pupils and teachers
  • Open-response quiz questions
  • Written teacher diaries during LEANS delivery
  • Child interviews
Headline findings

• Feasibility  
  Found NO major feasibility or acceptability issues
  YES: Got lots of practical feedback to improve resources

• Accessibility for pupils and teachers

• Safety for participating people  
  Found NO new safety issues, evidence of harms.
  YES: Evidence of changes to knowledge, attitudes, intended actions

• Impact
I loved the stories and characters but some stories were really long.

If I treat everyone the same way it could be unfair.

I didn't realise how many types of communication there are.

I also learned that some people might need different things to you to be successful.

People are different and shouldn't feel that they have to change.

I loved the stories and characters but some stories were really long.
"I think that studying LEANS genuinely made an impact on the class. Individual children... appeared to have a ‘penny drop’ moment...

I think it helped children to have a better understanding of the way others are/feel, and also why learning can be different and is delivered differently to them.”
Wanted more than was in the CALM talk?

Study pre-registration (quantitative measures only, includes copies of the measures): https://osf.io/38jrh

More detailed study summary: https://salvesen-research.ed.ac.uk/leans/about/evaluation
Connecting LEANS and CALM

Both take a “transdiagnostic” approach
...which is not business as usual in schools

Basic science from a study like CALM backs up the approach in LEANS, of focusing on neurodiversity and neurodivergence as bigger categories, rather than teaching people about individual diagnoses.

Applied work like LEANS is taking action now, offering tools to improve the school experiences of children, like those enrolled in CALM.

We CAN’T change the type of cognitive differences illustrated in the CALM findings, but we CAN change school environments and attitudes to expect and respect differences.
LEANS in summary

• A free curriculum for mainstream primaries, available NOW
  • Introduce pupils aged 8-11 years to the concept of neurodiversity
  • How it impacts our experiences at school
  • Teacher delivered, includes all you need, no required training

• Developed by a neurodiverse group of researchers and educators working together.

• Goals: to change what people know, think and intend to do regarding differences at school. Improve experiences.

• Evaluation evidence suggested LEANS is feasible, safe, and can change knowledge, attitudes, and intended actions.
LEANS is here.

Over 4800 downloads from around the world!

General project enquiries: LEANS@ed.ac.uk
My e-mail: a.alcorn@ed.ac.uk

Summer 2023 only: Alyssa.Alcorn@mrc-cbu.cam.ac.uk
Belonging at School

Coming in September 2023! New FREE resources for educators about neurodevelopmental differences, school inclusion, and co-designing inclusive policies.

Join our mailing list so you won’t miss them!

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