What are the behavioural difficulties of children who struggle in school?

Joe Bathelt, Joni Holmes, the CALM team, Duncan Astle
Behavioural difficulties: An example

- school performance markedly below grade level
- he has particular problems with reading learning difficulties?
- he has difficulties paying attention in class attention deficit?
- he often gets picked last in group assignments social difficulties?
- teachers describe him as disruptive
- David received a diagnosis of ADHD

David, 11 years
What does the diagnosis tell us about behavioural problems?

- 2-5% of children have an ADHD diagnosis
- high overlap with other problems, e.g.:
  - learning difficulties
  - problems with social adjustment
The CALM sample

- children who struggle in school with problems related to attention, learning, language, and/or memory
The CALM sample

- children who struggle in school with problems related to attention, learning, language, and/or memory
- referral by professionals working with children

<table>
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<tr>
<th>Referrer</th>
<th>Total</th>
<th>%</th>
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<tr>
<td>SENCo</td>
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<td>Private tutor</td>
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The CALM sample

- children who struggle in school with problems related to attention, learning, language, and/or memory
- referral by professionals working with children
- around a third had a diagnosis

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Total</th>
<th>%</th>
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<tbody>
<tr>
<td>None</td>
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<td>76.7</td>
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<tr>
<td>ADHD</td>
<td>61</td>
<td>15.6</td>
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<tr>
<td>Learning Deficit</td>
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<td>ASD</td>
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<tr>
<td>Other</td>
<td>23</td>
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</tr>
</tbody>
</table>
Behavioural Questionnaires

- everyday behavioural difficulties related to ADHD and common comorbidities (Conners-3 Short Form)

Inattention: Has trouble concentrating

Hyperactivity/Impulsivity:

- Fidgets or squirms in seat

Learning problems:

- Needs extra explanation of instructions

Executive function:

- Forgets to turn in completed work

Aggression:

- Starts fights with others on purpose

Peer relationships:

- Has trouble finding friends
Behavioural profiles of diagnostic groups

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<tr>
<th>Condition</th>
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<td>Learning Deficit</td>
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<td>None</td>
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</table>

The graph shows age-standardised scores across different domains:
- Inattention
- Hyperactivity/Impulsivity
- Learning Problem
- Executive Function
- Aggression
- Peer Relations

The clinical range is indicated by the dashed lines.
Behavioural profiles within diagnostic groups

example child #1
example child #2
example child #3
What does the diagnosis tell us about behavioural problems?

- behavioural problems associated with ADHD are non-specific
  - ADHD-related behaviours are common in struggling learners
  - children within a diagnostic group may have different profiles
Can we identify subgroups of children with similar behavioural problems?
one child

close together
→ more similar
Results

- the groups show similar profiles on other questionnaires that were not used to inform the clustering algorithm:

  C1 (executive deficit) shows problems with working memory, planning, and organisation of materials

  C2 (learning problems) shows no particular deficits relating to executive function compared to the other groups

  C3 (aggression) shows deficits in emotional control
Results

- the groups show similar profiles on other questionnaires that were not used to inform the clustering algorithm:

  C1 (executive deficit) shows problems with hyperactivity
  
  C2 (learning problems) shows no particular deficits
  
  C3 (aggression) shows problems with conduct, peer relationships, and prosocial behaviour
Results

- ratings of children within the data-driven groups are more similar to each other than children within diagnostic groups
- this is also the case for questionnaires that were not used to inform the algorithm
Results

Does the data-driven grouping relate to potential biological substrates?
Summary

- Data-driven clustering provided a robust grouping of ADHD-related behavioural problems.
- Three groups were identified: children with problems relating to
  1. Inattention, hyperactivity/impulsivity, and executive function
  2. Learning
  3. Aggression and peer relationships
- The groups were distinguishable by white matter connectivity of the prefrontal and anterior cingulate cortex.
Discussion

• machine learning can be used to identify groups of children with similar behavioural difficulties

• useful for:
  - more targeted intervention
  - research into the causes of these difficulties
Published article:

**Data-Driven Subtyping of Executive Function-Related Behavioral Problems in Children**

Joe Bathelt, PhD, Joni Holmes, PhD, Duncan E. Astle, PhD, on behalf of the Centre for Attention Learning and Memory (CALM) Team

**Objective:** Executive functions (EF) are cognitive skills that are important for regulating behavior and for achieving goals. Executive function deficits are common in children who struggle in school and are associated with multiple neurodevelopmental disorders. However, there is considerable heterogeneity across children, even within diagnostic categories. This study took a data-driven approach to identify distinct clusters of children with common profiles of EF-related difficulties, and then identified patterns of brain organization that distinguished these data-driven groups.

**Method:** The sample consisted of 442 children identified by health and educational professionals as having difficulties in attention, learning, and/or memory. We applied community clustering, a data-driven clustering algorithm, to group children by similarities on a commonly used rating scale of EF, associated behavioral difficulties, the Conners 3 questionnaire. We then investigated whether the groups identified by the algorithm could be distinguished on white matter connectivity using a structural connectivity approach combined with partial least square analysis.

**Results:** The data-driven clustering yielded distinct groups of children with symptoms of one of the following: (1) elevated attention and hyperactivity/impulsivity, and poor EF; (2) learning problems; or (3) aggressive behavior and problems with peer relationships. These groups were associated with significant interindividual variation in white matter connectivity, implicating the prefrontal and anterior cingulate cortices.

**Conclusion:** As such, the data-driven classification of EF-related behavioral difficulties identified stable groups of children, provided a good account of interindividual differences, and aligned closely with underlying neurobiological substrates.

**Key words:** executive function, childhood, neurology, structural imaging


https://doi.org/10.1016/j.jaac.2018.01.014

Editorial:

**“Communities” of Conditions: Novel Methods for Classifying Psychiatric Disorders**

David S. Hong, MD

In 1798, Philippe Pinel presented one of the first nosologies for psychiatric disorders, "Mémoire sur l'analyse appliquée à la médecine,"1 His emphasis on psychological and physical conditions as the basis of mental illness provided a distinct departure from prior reliance on etiologies such as demonic possession. Establishing classification schema was a much more profound innovation than a simple academic reordering of psychiatric phenomena—under Pinel’s leadership at the famed Hôtel-Dieu hospital, it also led to a radical reformation of clinical interventions, moving away from pseudoscientific practices toward psychologically based interventions. Much of this work influenced his successors in psychiatric taxonomy including Emil Kraepelin and others, ultimately forming the basis of the DSM.2 Although the DSM has been subsequently celebrated and maligned, it has been instrumental in both our conceptualization and treatment approach to psychiatric disorders. Indeed, there has been extensive effort to validate these conditions using factor analytic approaches to confirm that such conditions represent cohesive biologically based disorders, which has presented challenges.

In parallel, the field of statistics has undergone a dramatic transformation, particularly in the past several decades. Among the forefront of these developments has been the advent of machine-learning strategies, including graph theoretical approaches. Where prior medical research has relied on a priori assumptions of disease categories, graph theory allows groups to be defined without the restraint of these diagnostic presumptions, instead allowing the “shape” of the data to cluster individuals into groups of the most similar individuals based on a comprehensive set of variables. The implication of this approach in psychiatry is profound, given the reliance on phenomena to define groups with the guiding assumption that these categories share an underlying etiology. Indeed, recent implementations of machine-learning techniques in psychiatric research has been attracting attention,3 however, widespread use is still limited.

Bathelt and colleagues4 apply one such approach in the current edition of the Journal. In a naturalistic cohort of 642 youth (ages 5–18 years) in the United Kingdom who were referred from schools and community providers for having problems in attention, learning, or memory, the authors used parent-rated Conners subscale scores to determine whether this mixed population of youth could be separated into clusters or “communities” based solely on these ratings. Indeed, they found that youth could be separated into 3 distinct communities, characterized by differences in cognitive control domains (Attention, Hyperactivity/Impulsivity, and Executive Function subscale scores), learning difficulties (Learning Problems), or behavioral conduct problems (Aggression and Peer Relations). The authors also found significant differences among these groups on 2 behavioral functioning (Strengths and Difficulties Questionnaire [SDQ]). A subset of the sample (n = 148) had undergone brain imaging, allowing white matter connectivity patterns to be established for each individual. Again using the same 3 clusters identified in the data-driven approach, the authors determined several parameters of white matter connectivity that most effectively discriminated among these groups. Although there were similarities in connectivity patterns, there were also differences centering on lateral prefrontal and cingulate cortices, suggesting biological validity for the clustering approach.

This work provides a significant advance in psychiatric research, particularly for conditions at high heritability as attentional and learning disorders in which comorbidities reflect the norm rather than the exception. Many important advances are established in this type of research, including demonstrating the efficacy of data-driven graph theoretical approaches that both confirm phenomenological definitions while simultaneously providing an alternative recurrent diagnostic classification. Indeed, these methods are being used extensively in other domains for the similar purposes.5 Although there are specific caveats to this study’s findings for using single-patient-based rating scales and the need for more robust mapping of data-driven clustering approaches to current DSM-based diagnostic classifications, this type of research represents a new mainstay in how data will be analyzed in modern multidimensional frameworks.

Medicine is shifting away from the centuries-old innovations by Pinel and his peers, which relied on keen observation of psychological phenomena and subjective symptom reports in clinical settings. Instead, the advent of electronic medical records (EMR), mobile technology, and “digital phenotyping” suggests that soon this profound amount of data may become readily available to clinicians as part of their evaluations and treatment approaches. Methods such as the community detection model here represents one of many machine-learning statistical strategies that indicate the changing face of research methodology and the need for innovative approaches to effectively investigate these new forms of data, making it increasingly important to explore how these changes will affect future psychiatric practice.

https://doi.org/10.1016/j.jaac.2018.02.002
Thank you to the CALM team

in particular to:

Duncan Astle  Joni Holmes

Thank you for your attention!
Picture credits

David: https://upload.wikimedia.org/wikipedia/commons/8/8d/AJ_goodman_at_school.png
Other images: original work MRC Cognition & Brain Sciences Unit, University of Cambridge
What next for CALM?

Joni Holmes

CALM Annual Workshop, 9th June 2018
TO DATE
n=800 struggling learners

Education: n=447 (156)
CAMHS & Paediatrics: n=256 (61)
SLT: n=36 (15)

Referred to CALM n=739 (232)

Current sample n=650 (203)

Education: n=390 (134)
CAMHS & Paediatrics: n= 228 (55)
SLT: n=32 (14)
<table>
<thead>
<tr>
<th>Cognition</th>
<th>Attention</th>
<th>Episodic memory</th>
<th>Executive functions</th>
<th>Phonological processing</th>
<th>Processing speed</th>
<th>Nonverbal reasoning</th>
<th>Short term and working memory</th>
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<td>Genes</td>
<td>Saliva</td>
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Pathways to learning

<table>
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<tr>
<td>Hyperactivity</td>
<td>Social/ pragmatic communication</td>
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</table>
TYPICAL SAMPLE
Age norms

Cognition

Oppositional Inattention Hyperactivity ADHD Index

Behaviour

Oppositional Inattention Hyperactivity ADHD Index
CALM typically developing

- Schools
  - Attended by at least one SENCo referred child

- Aged 5-18 years

- All on school register, except
  - already referred to CALM
  - sensory impairments
  - non-native English speakers
Age norms and representative sample

Cognition

Behaviour
Are you a SENCo who has referred to CALM?
Example questions

Do pathways to learning change as children get older?

What predicts whether a child’s learning problems will resolve or persist?

Implications

Identify risk and resilience factors for persistent learning difficulties

Inform age-appropriate intervention approaches
MENTAL HEALTH
Learning and mental health problems co-occur
But separate fields of research

Data from CALM clinic
### LEARNING AND MENTAL HEALTH

<table>
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<th>STM</th>
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</thead>
<tbody>
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<td>Executive functions</td>
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<td>Nonverbal reasoning</td>
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<td>Behaviour</td>
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<td>Hyperactivity</td>
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<td>Peer relations</td>
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<td>Attention</td>
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<td>Aggression</td>
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<td>Emotion</td>
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<td>Environment</td>
<td></td>
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<tr>
<td>Abuse</td>
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<tr>
<td>Trauma</td>
<td></td>
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<tr>
<td>Poverty</td>
<td></td>
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</tbody>
</table>
Mental Health: A new clinic

Example questions

Do mental health problems and learning difficulties have common as well as distinct origins?

Can the causes of learning difficulties be distinguished for children who also have mental health problems?

Implications

Inform intervention approaches for children at developmental risk
All made possible by:

Susan Gathercole  Erin Hawkins  Previous
Duncan Astle    Sinéad O’Brien  Frankie Woolgar
Tom Manly       Laura Forde     Sara Gharooni
Rogier Kievit   Amy Johnson     Agnieszka Jaroslawska
Joni Holmes     Sarah Bishop    Erica Bottacin
Annie Bryant    Mengya Zhang    Gemma Crickmore
Fánchea Daly    Joe Rennie      Andrew Gadie
Sally Butterfield    Cliodhna O’Leary
Joe Bathelt      Silvana Mareva
Tina Emery       Lara Bridge    Andrea Kusac
                   Ivan Simpson-Kent
                   Delia Fuhrmann
                   Elizabeth Byrne
                   Alex Irvine
                   Giacomo Bignardi
OPEN DAY

MRC Festival of Medical Research

Cognition and Brain Sciences Unit
Come and learn more about the working brain and our research in psychology and neuroscience
Tours of the MRI and MEG scanners
Talks
Hands on experiments
Children's activities
Meet the scientists
History of brain research
Find out how to volunteer

Saturday 16 June 2018
10.00-16.00
MRC Cognition and Brain Sciences Unit
University of Cambridge
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Cambridge, CB2 7EF

Free admission
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01223 365294

#MRCfestival • mrc.ukri.org/mrcfestival
How are communication problems and hyperactivity related?

Silvana Mareva, The CALM team, & Joni Holmes
Structural aspects of language

- Producing fluent speech
- Grammar & Vocabulary
- Combining words into sentences

Dropping the “s” from present tense verbs:  
“He eat the cookie”

Asking questions without the usual “be” or “do” verb:  
“Why he like me?”
Pragmatic aspects of language

• Language use in everyday social settings
• Taking turns, staying on topic, not talking excessively
• Interpreting and using non-verbal cues
• Inferring subtle or non-literal meaning

➢ Pragmatic and structural difficulties do not always go hand in hand
Example

“The fish is on the table”

Integrate words with context
Cooked fish on table

Uncover speaker’s intention
“Come and eat!”

Bishop, 1997
• Pragmatic and social communication difficulties common in ADHD and ASD
  • Both also have elevated levels of hyperactivity, impulsivity, and poor behaviour
  • Previously in CALM we have seen that the severity of behavioural difficulties is associated with communication problems

Hawkins et al., 2016
• Why are behavioural difficulties and communication problems related?
• Difficulties in everyday cognitive skills like planning, organising, and remembering may impact both?
• Alternative: poor behaviour limits opportunities to develop communication skills?

➢ Look at how individual symptoms of hyperactivity & impulsivity may be related to communication skills
Again we can look at networks:

Each child is represented as a circle.

We can see how similar children are to one another.

Bathelt el al., 2018
We can see how individual symptoms relate to one another.
Why networks?

• Discover how symptoms are related
• Identify important symptoms in a network
• Paths: the shortest path from symptom A to symptom B
• Clustering: discover communities of symptoms
Let’s consider an example

We can plot the associations between symptoms

...but associations between symptoms can arise in multiple ways
Let’s consider an example

We can plot the associations between symptoms

Association may arise because activation of one symptom causes the second symptom
Let’s consider an example

We can plot the associations between symptoms.

Association may arise because activation of one symptom causes the second symptom.
Association between symptoms may be due to shared association with a third symptom

...association may not be very informative about the causal paths of activation
If we want to identify relations between symptoms, which are not due a third symptom...

..we can look at concentration networks

They represent associations remaining after one has accounted for the influence of all other symptoms in the network.
If we want to identify relations between symptoms, which are not due a third symptom...

..we can look at concentration networks

They represent associations remaining after one has accounted for the influence of all other symptoms in the network
Concentration Networks

Important caveat: Even with concentration networks there are multiple ways in which the relationship can occur.

The network remains undirected: We don’t know the direction of causality.
Concentration Networks

Important caveat: Even with concentration networks there are multiple ways in which the relationship can occur

The network remains undirected. We don’t know the direction of causality

Some links are more plausible than others
Important caveat: Even with concentration networks there are multiple ways in which the relationship can occur.

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Some links are more plausible than others.
Important caveat: Even with concentration networks there are multiple ways in which the relationship can occur. The network remains undirected. We don’t know the direction of causality. Some links are more plausible than others.
Apply this framework to understand how symptoms of behavioural and social communication difficulties relate to one another.

Uncover associations remaining after taking into account all other symptoms in the network.
“In the past months how often does this happen:

Never, Occasionally, Often, Very often?”

**Inattention**
‘Doesn’t pay attention to details, makes careless mistakes’

**Hyperactivity/Impulsivity**
‘Runs or climbs when he/she is not supposed to’

**Learning problems**
‘Needs extra explanation of instruction’

**Executive Functions**
‘Has trouble organising tasks or activities’

**Aggression**
‘Starts fights with others on purpose’

**Peer Relationships**
‘Does not know how to make friends’
Behaviour Rating Inventory of Executive Function

“Is this behaviour a problem:

Never, Sometimes, Often?”

Planning
‘Has good ideas but cannot put them on paper’

Organisation
‘Leaves a trail of belongings wherever he/she goes’

Working Memory
‘Forgets what he/she was doing’

Shifting
‘Acts upset by change of plans’

Initiation
‘Is not a self-starter’

Inhibition
‘Gets in trouble if not supervised by adult’

Emotional Control
‘Overreacts to small problems’

Monitoring
‘Does not realise that certain actions bother others’
Children’s Communication Checklist

“How often does this happen:

Never, Once a week, Once or twice a day, Several times a day?”

Structural Language Skills

Speech

“Speaks fluently and clearly’

Syntax

“Leaves off past tense ‘-ed’ endings on words”

Semantics

“Mixes up words of similar meaning”

Coherence

“Hard to tell if s/he is talking about something real or make—believe ”
Children’s Communication Checklist

“How often does this happen:

Never, Once a week, Once or twice a day, Several times a day?”

Pragmatic Communication Skills

Inappropriate Initiation

“Asks a question, even though s/he has been given the answer”

Stereotyped use

“Uses favourite phrases, sentences or longer sequences”

Use of context

“Gets confused when a word is used with a different meaning from usual”

Nonverbal

“Does not look at the person s/he is talking to”

Social

“Talks about his/her friends; shows interest in what they—do and say”

Interests

“Moves the conversation to a favourite topic, even if others don’t seem interested in it”
506 children, 70% male, average age = 9.22

<table>
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<tr>
<th>Diagnosis</th>
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<tr>
<td>ASD</td>
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<td>Comorbidity (more than one</td>
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<td>diagnosis)</td>
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*Note. ADHD= attention-deficit/hyperactivity disorder; ASD=autism spectrum disorder*

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</tr>
<tr>
<td>Private Tutor</td>
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</tbody>
</table>

*Note. SENCo = special educational needs coordinator.*
Symptom Network: Behaviour & Communication

Lines represent associations remaining after accounting for all other symptoms in the network.

Thicker lines represent stronger associations.

Symptom colour depicts symptom cluster.

**Pragmatic Communication**
- Peer: Peer Relations (Conners-3)
- Coher: Coherence (CCC-2)
- Inap.Init: Inappropriate Initiation (CCC-2)
- Stereo: Stereotyped Use (CCC-2)
- Context: Use of Context (CCC-2)
- Nonver: Nonverbal Communication (CCC-2)
- Social: Social relations (CCC-2)
- Interest: 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)
Which are the important symptoms?

We can look at the importance of each symptom:

**Strength**: sum of all weights (i.e., association magnitudes) linked to the symptom

**Betweenness**: the number of times that a symptom lies on the shortest path between two other symptoms

- Symptoms high on these metrics may be useful targets for interventions
Which are the important symptoms?

- Inhibition
- Working Memory
- Inappropriate Initiation
- Use of Context
- Social communication

[Graph showing z scores for different measures including Inatt, Hyp, Learn, EF, Agg, Peer, Inhib, Shift, Emot, Init, WM, Plan, Org, Mont, Speech, Synt, Seman, Coher, Inap. Init, Stereo, Context, Nonver, Social, Interest, with lines for Betweenness and Strength]
Symptom Network: Behaviour & Communication

- **Pragmatic Communication**
  - Peer: Peer Relations (Conners-3)
  - Coher: Coherence (CCC-2)
  - Inap.Initi: Inappropriate Initiation (CCC-2)
  - Stereo: Stereotyped Use (CCC-2)
  - Context: Use of Context (CCC-2)
  - Nonver: Nonverbal Communication (CCC-2)
  - Social: Social relations (CCC-2)
  - Interest: 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)
  - Initi: Initiation (BRIEF)
  - WM: Working Memory (BRIEF)
  - Plan: Planning (BRIEF)
  - Org: Organisation (BRIEF)
Network Approach: Insights

• Structural language more important for Learning
  • Few links between structural language and everyday cold cognitive skills suggest separate domains that may both be important for learning
Network Approach: Insights

- Structural language more important for Learning
  - Few links between structural language and everyday cold cognitive skills suggest separate domains that may both be important for learning
  - Everyday cognitive skills may impact learning, which in turn may impair one’s ability to acquire language skills
Network Approach: Insights

• Pragmatic skills, behavioural difficulties, & peer relationships are closely inter-related:
  • High centrality of communication abilities suggests that poor behaviour may be limiting a child’s opportunities to acquire social communication skills
  • High centrality of Inhibition and Working memory skills suggests that the link may also be underpinned by difficulties in everyday cognitive skills

➢ Targeting these high centrality symptoms may help alleviate other symptoms in the network
Thank you!

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All referrers, families, & children!
Why do some learners struggle?

• Difficulties in learning (language, reading, maths) are common

• These problems often co-occur and have overlapping symptoms
e.g., memory, attention, inattention

• Diagnoses vary

• The difficulties may be better explained in terms of broad dimensions that can be targeted for interventions

• What are these dimensions in a mixed, representative population of children with cognitive problems?
The CALM research clinic

- Recruited children receiving additional support from 5 to 16 years from education and health services

- Problems with attention, learning and/or memory

- Only exclusions were sensory impairments and English as a non-native language

- One 3-hour clinic visit, plus brain imaging
Clinic assessments

<table>
<thead>
<tr>
<th>COGNITION</th>
<th>LEARNING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attention</td>
<td></td>
</tr>
<tr>
<td>Episodic memory</td>
<td></td>
</tr>
<tr>
<td>Executive</td>
<td></td>
</tr>
<tr>
<td>functions</td>
<td></td>
</tr>
<tr>
<td>Phonological</td>
<td></td>
</tr>
<tr>
<td>processing</td>
<td></td>
</tr>
<tr>
<td>Processing speed</td>
<td></td>
</tr>
<tr>
<td>Nonverbal</td>
<td></td>
</tr>
<tr>
<td>reasoning</td>
<td></td>
</tr>
<tr>
<td>Short term and</td>
<td></td>
</tr>
<tr>
<td>working memory</td>
<td></td>
</tr>
</tbody>
</table>

| BEHAVIOUR       |                                                                           |
| Executive       | functions, attention, communication, mental health                       |
| attention       |                                                                           |
| communication   |                                                                           |
| mental health   |                                                                           |

| BRAIN           |                                                                           |
| Structural MRI  |                                                                           |
| diffusion-weighted imaging, resting-state | |

| GENES           |                                                                           |
| Saliva          |                                                                           |
Recruitment

Education: n=447 (156 g)
Mental health & Paediatrics: n=256 (61 g)
Speech & Language therapy: n=36 (15 g)

739 (232) referred

Current sample 650 (203)

Education: n=390 (134)
CAMHS & Paediatrics: n=228 (55)
SLT: n=32 (14)

Target: 800 children
<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADD</td>
<td>11</td>
</tr>
<tr>
<td>ADHD</td>
<td>137</td>
</tr>
<tr>
<td>Possible ADHD</td>
<td>55</td>
</tr>
<tr>
<td>Hyperactivity</td>
<td>1</td>
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<tr>
<td>Dyslexia</td>
<td>35</td>
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<tr>
<td>Dyspraxia</td>
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<td>Dysgraphia</td>
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<tr>
<td>Dyscalculia</td>
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<tr>
<td>FASD</td>
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<tr>
<td>Generalised/global delay</td>
<td>7</td>
</tr>
<tr>
<td>Social anxiety</td>
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<tr>
<td>Depression</td>
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<tr>
<td>ASD</td>
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<td>PDA</td>
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<tr>
<td>Tourettes</td>
<td>5</td>
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<td>DAMP</td>
<td>4</td>
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<tr>
<td>Anxiety</td>
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<td>OCD</td>
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<tr>
<td>Sensory processing disorder</td>
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</tr>
<tr>
<td>Language disorder</td>
<td>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</td>
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<tr>
<td>Speech &amp; language therapy support</td>
<td>123</td>
</tr>
<tr>
<td>No diagnosis</td>
<td>407</td>
</tr>
</tbody>
</table>
Do ADHD symptoms cause learning difficulties?

• ADHD is characterised by two kinds of behavioural problems:
  i) hyperactivity/ impulsivity
  ii) inattention

• ADHD is often but not always accompanied by learning problems

• Children without ADHD who struggle to learn are also typically inattentive but not hyperactive/ impulsive.

• Their learning problems problems usually originate in weak cognitive skills.
Are the causes of the learning difficulties the same in both cases?

... or do high levels of hyperactive and impulsive behaviour cause learning difficulties in ADHD?
Numbers of children with ADHD, reading and maths difficulties

Do the learning problems of the children with and without ADHD have the same causes?
Group profiles of learning, cognition and behaviour

Learning

Cognitive skills
Group profiles of learning, cognition and behaviour

Learning

Cognitive skills

Behaviour

Not for forward circulation – preliminary results
Impacts of cognition and behaviour on learning

COGNITION

- Phonological skills
- Spatial/executive skills
- Processing speed

LEARNING

- Reading
- Maths
Impacts of cognition and behaviour on learning

COGNITION

Phonological skills

Spatial/ executive skills

Processing speed

LEARNING

Reading

Maths
Impacts of cognition and behaviour on learning

**COGNITION**

- Phonological skills
- Spatial/executive skills
- Processing speed

**LEARNING**

- Reading
- Maths
Impacts of cognition and behaviour on learning

**COGNITION**

- Phonological skills
- Spatial/ executive skills
- Processing speed

**LEARNING**

- Reading
- Maths
Impacts of cognition and behaviour on learning

COGNITION

- Phonological skills
- Spatial/ executive skills
- Processing speed

LEARNING

- Reading
- Maths

BEHAVIOUR

- Inattention
Impacts of cognition and behaviour on learning

COGNITION       LEARNING       BEHAVIOUR

- Phonological skills
- Spatial/ executive skills
- Processing speed

- Reading
- Maths

- Hyperactivity/ impulsivity
- Inattention

Not for forward circulation – preliminary results
Summary

1. Learning problems are strongly linked with cognitive skills:
   - phonological skills with reading
   - maths abilities most strongly with spatial executive skills, and also with phonological skills and processing speed

2. Learning in ADHD is unaffected by hyperactive and impulsive behaviour

3. Inattentive behaviour is linked with learning problems for all children

**ADHD = behaviour problems associated with emotional control**
+ *(for many children)* poor cognitive skills
CALM ‘typical’ children: why are they at the clinic?

![Venn diagram showing the relationship between ADHD, Reading difficulties, and Maths difficulties.]
Profiles of learning, cognition and behaviour in CALM typical learners

Not for forward circulation – preliminary results
Profiles of learning, cognition and behaviour in CALM typical learners

Not for forward circulation – preliminary results
Summary

1. Do cognitive deficits cause reading and maths problems? Yes

2. Do ADHD symptoms cause learning difficulties? No

3. Are learning-related problems always evident in tests of cognition and learning? No

The ‘typical’ CALM learners have weak executive behaviours but no obvious cognitive or learning problems.

• Have they been remediated?
• Do these children struggle in the classroom but not the clinic?
Implications

Children with ADHD and learning problems
• require support both for ADHD symptoms and for learning difficulties
• best-practice interventions for literacy likely to be of equal benefit for children with and without ADHD

Some children have behaviour problems in learning situations without measurable deficits in learning or cognition
• how can we best support these children?
• is inattention in classroom situations the biggest problem?