Developmental Coordination Disorder

...A focus on handwriting

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What is Developmental Coordination Disorder (DCD)?

It is the term used to refer to children who present with motor coordination difficulties, unexplained by a general medical condition, intellectual disability or neurological impairment.

American Psychiatric Association [APA], 2000
IMPACT OF DCD

Home
Feeding
Washing
Dressing

School
Handwriting
Lunch
PE
Handwriting & Children with DCD

Listed as one of the most common concerns & difficulties in children with DCD

One of the most significantly impacted activities (Miller et al, 2001).

One of the most common reasons for referral to Occupational Therapy for school age children (Feder et al., 2000)

UK Context
THE WRITING PROCESS


Text generation (word, sentence, paragraph level)

Working memory*

Transcription (handwriting, keyboarding and spelling)

Executive functions (conscious attention, planning, reviewing, revising, strategies for self-regulation)

Note. *activates long-term memory during composing and short-term memory during reviewing
Model of handwriting: Van Galen (1991)

Cognitive/linguistic

1. Activate intentions
2. Semantic retrieval
3. Syntax
4. Spelling
5. Selection of allographs

Motor

1. Size control
2. Muscular adjustment
3. Real-time movement
ATYPICAL HANDWRITING

Model of handwriting: Van Galen (1991)

Cognitive/linguistic:
- Activate intentions
- Semantic retrieval
- Syntax
- Spelling
- Selection of allographs

Motor:
- Size control
- Muscular adjustment
- Real-time movement

Conditions:
- DCD
- ASD
- Cerebral Palsy
- Learning Disability
- ADHD
- SLI
What We Hear

Verbal descriptions of handwriting difficulties in DCD

**Jordan:**
At referral he was having difficulty writing his letters

**Mark:**
His handwriting is just legible but very slow

**Matt:**
At referral he was having difficulty with his letters and complained of his hand tiring easily

(Polatajko & Mandich, 2004; Sugden & Chambers, 2002)
The Work Done So Far

Rosenblum et al, 2003;2008

Supporting Observations

- Distinct slowness in all tasks
- Below peers in global legibility
- Poor spatial arrangement

Additional Findings

- Considerable extra time in-air
- More letters rectified (erased or overwritten)

Rosenblum et al, 2003;2008
To assess the speed of handwriting performance in children with DCD in English by:


2. Comparing the temporal aspects of the handwriting process in children with and without DCD on this range of writing tasks.
Participants & Selection Measures
### DCD Group Selection

Primarily recruited through the community

**Criteria for database:**

<table>
<thead>
<tr>
<th>DSM-IV Criterion for DCD</th>
<th>Assessments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A</strong> Performance in daily activities that require motor coordination is substantially below that expected</td>
<td>• Phone interview with parent</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>B</strong> Interferes with academic achievement or activities of daily living.</td>
<td>• Movement Assessment Battery for Children (M-ABC-2) including checklist (Henderson et al., 2007)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>C</strong> Not due to a general medical condition</td>
<td>• British Pictorial Vocabulary Scale (receptive vocabulary) (Dunn et al., 2009)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>D</strong> Not due to intellectual disability</td>
<td></td>
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</table>
DCD Group Selection

Additional Assessments in.....

<table>
<thead>
<tr>
<th>Reading</th>
<th>Spelling</th>
</tr>
</thead>
</table>

British Ability Scales (BAS)
(Elliott, 1996)
<table>
<thead>
<tr>
<th>Inclusion Criteria</th>
<th>Assessments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor skills within the average range expected for their age</td>
<td>• Movement Assessment Battery for Children (M-ABC) including checklist (Henderson et al., 2007)</td>
</tr>
<tr>
<td>Receptive vocabulary, reading and spelling ability all within average range expected for their age</td>
<td>• BAS-II Reading &amp; spelling (Elliott, 1996)</td>
</tr>
<tr>
<td></td>
<td>• British Pictorial Vocabulary Scale (BPVS) (Dunn et al., 2009)</td>
</tr>
</tbody>
</table>
## Background

### Participants & Selection Measures

<table>
<thead>
<tr>
<th>Measures</th>
<th>DCD n=28</th>
<th>SD</th>
<th>TD n=28</th>
<th>SD</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age:</td>
<td>10.61</td>
<td>2.23</td>
<td>10.95</td>
<td>2.12</td>
<td>.441</td>
</tr>
<tr>
<td>M-ABC Percentile</td>
<td>3.45</td>
<td>2.96</td>
<td>43.37</td>
<td>25.4</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>BPVS</td>
<td>109</td>
<td>14</td>
<td>110</td>
<td>12</td>
<td>.655</td>
</tr>
<tr>
<td>BAS-Reading</td>
<td>110</td>
<td>13.8</td>
<td>122</td>
<td>12.6</td>
<td>.001*</td>
</tr>
<tr>
<td>BAS-Spelling</td>
<td>96</td>
<td>13.7</td>
<td>111</td>
<td>12.7</td>
<td>&lt;.001*</td>
</tr>
</tbody>
</table>
Methods
Handwriting Product

Detailed Assessment of Speed of Handwriting (DASH; Barnett et al, 2007)

- Copy Best task
- Alphabet task
- Copy Fast task
- Free-writing task - ‘my life’
- Name writing
COPYING TASKS

The quick brown fox jumps over the lazy dog

Copy Best: Copy the above sentence in their ‘best’ handwriting for two minutes.

Copy Fast: Copy the above sentence as quickly as possible for two minutes making sure every word is readable.

ALPHABET TASK

Write the letters of the alphabet from memory as quick as possible for one minute.
FREE WRITING TASK- ‘MY LIFE’
Handwriting Process

Writing Tablet


- Duration of the tasks
- Execution speed (cm/s)
- Percentage of time spent pausing during tasks
THE SET-UP
Results
<table>
<thead>
<tr>
<th>DASH Raw Scores</th>
<th>DCD n=28</th>
<th>TD n=28</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alphabet (lpm)</td>
<td>37.64 (17.31)</td>
<td>53.57 (17.05)</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>Copy Best (wpm)</td>
<td>12.64 (5.76)</td>
<td>17.14 (5.52)</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>Copy Fast (wpm)</td>
<td>14.93 (6.28)</td>
<td>22.39 (7.09)</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>Free-Writing (wpm) 10 mins</td>
<td>11.99 (6.07)</td>
<td>15.67 (4.41)</td>
<td>.003*</td>
</tr>
</tbody>
</table>
Execution Speed (cm/s) on Handwriting Tasks
Pausing Percentages on Handwriting Tasks

[Bar chart showing pausing percentages for different tasks: Copy Best, Copy Fast, Alphabet, Free-writing, Name. The chart compares DCD (pink) and TD (green) conditions. Significant differences are marked with an asterisk (*).]
Handwriting Performance of children with DCD

- Below their TD peers in the raw scores of all DASH tasks
- Execution speed similar to peers on all handwriting tasks
- Pause for a greater percentage of all handwriting tasks
Pause Analysis
Pausing at Letter Level

Pauses between 30-250ms & 1-2s

Pausing at Word Level

Pauses between 2-4s

Long Pauses

Pauses 4-10s & >10s

What the Thresholds are Thought to Represent

The graphomotor component

Difficulties with manipulating the pen between letters?

Higher level writing processes such as planning

Breakdowns at the word level - Unable to plan online?

Planning? Fatigue?

Do they get tired? Do they need time to plan content?
## Pausing Profiles

<table>
<thead>
<tr>
<th></th>
<th>DCD n=28</th>
<th>TD n=28</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pause Thresholds</strong></td>
<td>M</td>
<td>M</td>
<td>p</td>
</tr>
<tr>
<td><strong>Letter Level</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30ms-250ms</td>
<td>21%</td>
<td>20%</td>
<td>.721</td>
</tr>
<tr>
<td>250ms-2s</td>
<td>37%</td>
<td>46%</td>
<td>.032*</td>
</tr>
<tr>
<td><strong>Word Level</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-4s</td>
<td>14%</td>
<td>15%</td>
<td>.272</td>
</tr>
<tr>
<td><strong>Long Pauses</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-10s</td>
<td>14%</td>
<td>14%</td>
<td>.874</td>
</tr>
<tr>
<td>&gt;10s</td>
<td>14%</td>
<td>5%</td>
<td>.032*</td>
</tr>
</tbody>
</table>
Long Pauses
The sports I choose to play are Rugby, Football, and Judo. Out of them all, Rugby is my favourite, besides at the fast, remarkable action and the damn geology but fun nature of the game. I do Judo regularly but it is still not as good as Football, which I do more often. Football is

Text generation (word, sentence, paragraph level)

Working memory*

Transcription (handwriting, keyboarding and spelling)

Executive functions (conscious attention, planning, reviewing, revising, strategies for self-regulation)

Possible Fatigue

10 Second Pauses

Conscious Attention
Planning
Revising

*activates long-term memory during composing and short-term memory during reviewing
Within Word Pauses
EXPLORING THE LACK OF AUTOMATICITY

Model of handwriting: Van Galen (1991)

Cognitive/linguistic

Motor

Activate intentions → Semantic retrieval → Syntax → Spelling → Selection of allographs → Size control → Muscular adjustment → Real-time movement
Boy with DCD aged 13.02 years - First 4 minutes of the DASH Free-writing

Within word pausing

TD boy aged 13.02 years - First 4 minutes of the DASH Free-writing

I like living with my family because. If we live here really well and go to school things go well. I have lots of friends at school and I do well in school.

During the holidays I am going to Menorca near Spain. It's always really hot and I love it there. We have been going to Menorca for 4-5 years now and my family still love it. In my family there is my sister, Madi, my mum, Nicole and my dad called David. We have a cat called Thistle. She's really old and fat! My hobbies are playing on the PlayStation, going out with my friends, playing lots of sports like football and tennis. I also like watching TV and one of my favourite programmes is "Top Gear". I have also been swimming.
EXPLORING THE LACK OF AUTOMATICITY

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- Activate intentions
- Semantic retrieval
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- Spelling
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Motor

- Size control
- Muscular adjustment
- Real-time movement
A boy with DCD, 10 years 1 month old.

Copy Best Task

The quick brown fox jumps over the lazy dog.
The quick brown fox jumps over the lazy dog.
The quick brown fox jumps over the lazy dog.

Copy Fast Task

The quick brown fox jumps over the lazy dog.
The quick brown fox jumps over the lazy dog.
The quick brown fox jumps over the lazy dog.
EXPLORING THE LACK OF AUTOMATICITY

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Motor

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Copy Best Task

Boy with DCD, 10 years 1 month old

The quick brown fox jumps over the lazy dog.
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The quick brown fox jumps over the lazy dog.
The quick brown fox jumps over the lazy dog.
The quick brown fox jumps over the lazy dog.
The quick brown fox jumps over the lazy dog.

Text generation (word, sentence, paragraph level)

Working memory*

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Possible Fatigue

Within word Pauses

Selection of Allograph

Size Control

10 Second Pauses

Conscious Attention
Planning
Revising

These are linked in the literature
Case Comparisons
Copy Best Task

Boy with DCD, 10 years 1 month old

Typically developing age and gender matched peer

The quick brown fox jumps over the lazy dog.
The quick brown fox jumps over the lazy dog.
The quick brown fox jumps over the lazy dog.
The quick brown fox jumps over the lazy dog.
Copy Fast Task

Boy with DCD, 10 years 1 month old

Typically developing age and gender matched peer

The quick brown fox jumps over the lazy dog.

The quick brown fox jumps over the lazy dog.

The quick brown fox jumps over the lazy dog.

The quick brown fox jumps over the lazy dog.
Free-Writing Task

- Take a good rest
- Played a lot of games
- Went to bed early
- Got up early
- Went to school
- Play with my friends
- Learn about history
- Pizza
- Chicken
- Veggies
- Eat a lot of healthy food
- Do a few clubs
- Learn to code
- Do some sports
- Out to do some fun things
- Enjoy the weekend
I am a member of the RSPB and RNC and so I get magazines from both regularly. I have three brothers and two sisters. My mum is one of ten children. I like playing football. I go birdwatching and in the October half term I went on a birdwatching camping trip. We went to Teesmarsh Nature Reserve and saw one of Britain's rarest birds: the butternut. Also we saw avocets, black-tailed godwits etc. My birthday is on the twenty-third of September 2002. I like reading books and the other day I counted all my books and guess what? I had one hundred and thirty five!!! I have recently purchased a new bookcase. I have two pet stick insects at the moment and there are still six waiting.
I play football. I play for Caerston and we were 3rd in the League but the season has finished so I can't play any more. I like watching baseball and playing it. I have loads of friends. My favorite hobbies are playing with my cars and Lego. I don't have any pets but I'm going to get a cocker spaniel and I'll call it Bailey.

I'm going on a holiday at Breamham which is in Plymouth. My favorite television program is The Simpsons and Top Gear. I go to a club called CUBS and we are going on a camp. Today my birthday is on the 23rd of May. My birthday is in 5 days time. I don't like dancing but I have a favorite dance, it is the Macarena.

My great grandmother is still alive but he is 84 years of age. He served in the
Theoretical Implications

Difficulties in the handwriting component of transcription

- Producing less words on the page than peers
- Pause for long periods of time
- Pause within words
- Legibility is a significant issue
DISCUSSION

Practical Implications

- Emphasises the importance of intervention rather than consultation to develop automaticity in their handwriting
- May support a focus on the ‘task’ of handwriting
- Evidence to support extra time in examinations for this population in the UK?
Questions?

Thank you for listening!

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