EXECUTIVE FUNCTION AND PHONOLOGICAL DISORDERS

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Research Question

- What mental processes are involved in the acquisition of phonological rules?
“top-down” cognitive inputs that facilitate decision-making by maintaining information about possible choices in working memory and integrating this knowledge about the current context to identify optimal action

Wilicutt, Doyle, Nigg, Faronne & Pennington (p.1336, 2005)
Barkley’s Model of EF: Mental Processes

- **Response Inhibition**: capacity to delay a response to an immediate environmental event
- **Nonverbal Working Memory**: capacity for imitation, self-awareness, social exchange and organization of behavior over time
- **Verbal Working Memory**: internalization of speech *rule discovery and rule-governed behavior*
- **Emotion**: motivational state
- **Reconstitution**: consists of 2 interacting processes - *analysis* (taking apart) and *synthesis*
Language and Executive Function

- **Language mediates executive function**

  Children use language to control their learning, behaviour and social interaction by participating in context-specific scripts and conscious metacognitive routines that develop over time and across contexts.

- **Implication**
  Language disorder leads to impaired executive function resulting in learning disabilities BUT…
Does executive function have a role in language acquisition?
The literature implies that children learn spoken language and then use spoken language as part of executive function to learn.
Socio-cognitive abilities provide a foundation for language learning (Locke, 1997)
Phonological Acquisition and Executive Function

- Phonology is a code: sequences of sounds that represent objects and abstract concepts.
- To both understand what others say and express their needs and thoughts, children must ‘crack’ that code: learn the contrasts and phonotactic rules of their language.
Phonological Acquisition

- Young children’s speech is characterized by consistent error patterns thought to reflect the application of linguistic rules
- For example:
  - so for snow, seep for sleep, sing for swing
  - but
  - poon for spoon, tep for step, ky sky
  - mine, mum, man all correct
  - but
  - bap for map, bike for Mike, bat for mat
Explaining Young Children’s Speech Errors

- Most children share the same error patterns at around the same age, but these error patterns change over time.
- One plausible explanation relies on children’s cognitive ability to discover the system of phonological contrasts and phonotactics of their language.
- Mental abilities allowing rule governed behaviour might be associated with phonological development.
Research Questions

- Is the ability to abstract rules and implement them flexibly associated with phonological development?
  - Can young children explicitly derive rules?
  - Do children with a consistent disorder perform less well than controls on the rule tasks?
  - Do children with different types of surface error patterns (consistent errors, and inconsistent errors) perform differently on the rule tasks?
Task 1: Flexible Item Selection Test

- FIST - Jacques & Zelazo, 2001
- A test of abstraction and cognitive flexibility for pre-school aged children
- Which two fish go together? Which other two fish go together?
Task 2: Rule Derivation

Rule 1: Touch the red shape
Rule 2: Touch the blue shape
Rule 3: Touch the circle
Rule 4: Touch the **blue** triangle
Typical Children’s Development
n=67 (31 girls, 36 boys)

<table>
<thead>
<tr>
<th>Group</th>
<th>Age</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3;0-3;5</td>
<td>14</td>
</tr>
<tr>
<td>2</td>
<td>3;6-3;11</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>4;0-4;5</td>
<td>19</td>
</tr>
<tr>
<td>4</td>
<td>4;6-5;8</td>
<td>22</td>
</tr>
</tbody>
</table>
FIST Results: Typical Development

- 3;0-3;5
- 3;6-3;11
- 4;0-4;5
- 4;6-5;8

Legend:
- FIST 1
- FIST 2
Number of Rules Learned

- 3;0-3;5
- 3;6-3;11
- 4;0-4;5
- 4;6-5;8

Rules Learned
Statistical Analyses

- Typical Development
  - FIST 1: Group 1 (youngest) < Groups 2, 3, 4
  - FIST 2: Group 1 < 2 < 3 = 4
  - Rule Learning: Group 1 = 2 < 3 = 4
Atypical Phonological Development

- Delayed Development: Error patterns evident typical of a child of a younger chronological age: cluster reduction

- Disordered Development: some phonological error patterns that are atypical of normal development
  - All initial consonants delete: [at] for cat, hat, mat, rat
  - All alveolar plosive and fricative sounds realized as a voiceless velar plosive: [kɪk] for sit, fit, tick
## Controls vs Consistent Disorder

<table>
<thead>
<tr>
<th>Group</th>
<th>Age (months)</th>
<th>Girls</th>
<th>Boys</th>
<th>Total</th>
<th>Language /30</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Controls</strong></td>
<td>53.4 (6)</td>
<td>9</td>
<td>29</td>
<td>38</td>
<td>20.9 (4)</td>
</tr>
<tr>
<td><strong>Consistent Disorder</strong></td>
<td>52.6 (8)</td>
<td>5</td>
<td>20</td>
<td>25</td>
<td>20.8 (4)</td>
</tr>
</tbody>
</table>
Typical vs Consistent Disorder

![Bar chart showing comparison between Control and Consistent Disorder for FIST 1, FIST 2, and Rule Learning.](chart.png)
Statistical Analysis

- Typical vs Consistent Disorder
  - FIST 1: NS
  - FIST 2: Consistents < Controls
  - Rule learning: Consistents < Controls
Inconsistent Errors

- 40% inconsistency in single word production when a set of 25 words are produced three times within one session, each trial separated by another activity
Inconsistent vs Consistent Disorder

<table>
<thead>
<tr>
<th>Speech Disorder</th>
<th>Inconsistent N=15</th>
<th>Consistent N=15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (months)</td>
<td>66 (9.5)</td>
<td>63 (7.0)</td>
</tr>
<tr>
<td>Percent Inconsistency</td>
<td>54.27 (12.1)</td>
<td>25.27 (8.1)</td>
</tr>
<tr>
<td>PCC</td>
<td>38.87 (13.8)</td>
<td>47.27 (18.8)</td>
</tr>
</tbody>
</table>
Consistent vs Inconsistent

- FIST 1: Consistents < Inconsistents
- FIST 2: Consistents < Inconsistents
Summary

- Phonological ability is linked with executive function rule abstraction and flexibility tasks.
- Explicit awareness of rules improves developmentally.
- Children with speech disorder who make consistent atypical errors perform less well than controls and other speech disordered children.
- The link between spoken and written phonological disorders may be an impaired ability to abstract and implement rules.