Understanding the influence of cognition and the home learning environment on early number skills

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What are early number skills and why are they important?

- Skills relating to number and quantity
- Large individual differences at school entry
- Predict substantial variance in later academic attainment
What could influence early number skills development?

**Language & Cognition**
- Vocabulary, phonological awareness, executive functioning, reasoning

**Environment**
- Home experiences
- Preschool experiences

**Biology**
- Genetics
- Brain function
Core Research Questions

1. To what extent do preschool language and cognitive skills predict growth in early number skills?

2. To what extent do number-oriented and language- and literacy-oriented aspects of the home learning environment predict growth in early number skills?

3. To what extent are the relationships between the quality of the home learning environment and early number skills direct and to what extent are they indirect via the promotion of language skills?
## The study

<table>
<thead>
<tr>
<th>Time point</th>
<th>Spring Term Preschool</th>
<th>Summer Term Preschool</th>
<th>Summer Term Reception</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$T_{1a}$</td>
<td>$T_{1b}$</td>
<td>$T_{2a}$</td>
</tr>
<tr>
<td></td>
<td>274</td>
<td>274</td>
<td>266</td>
</tr>
<tr>
<td>Mean age</td>
<td>3:11 (3.6)</td>
<td>4:0 (3.6)</td>
<td>4:3 (3.7)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5:3 (3.6)</td>
</tr>
<tr>
<td>Sample size</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measures at this time point</td>
<td>Home learning environment questionnaire</td>
<td>Early number skills assessments</td>
<td>Language and cognitive assessments</td>
</tr>
</tbody>
</table>
## Questionnaire items

<table>
<thead>
<tr>
<th>Home Number Experiences</th>
<th>Home Literacy Experiences</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number</strong></td>
<td><strong>Code-focused</strong></td>
</tr>
<tr>
<td>Is taught the names of <strong>numbers</strong></td>
<td>Talks about <strong>letter sounds</strong></td>
</tr>
<tr>
<td></td>
<td>with an adult</td>
</tr>
<tr>
<td>Writes or traces <strong>number</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Discusses <strong>numbers or quantity</strong> with an adult</td>
<td>Is taught the <strong>names or sounds of letters</strong></td>
</tr>
<tr>
<td>Is encouraged to point out or identify <strong>numbers</strong> in</td>
<td></td>
</tr>
<tr>
<td>books</td>
<td></td>
</tr>
<tr>
<td>Completess <strong>number activities</strong> in magazines or</td>
<td>Forms or traces <strong>letters</strong> or</td>
</tr>
<tr>
<td>workbooks</td>
<td>writes their name</td>
</tr>
<tr>
<td>Plays games that involve <strong>number</strong> cards, dice or a</td>
<td>Is prompted to identify <strong>letters</strong> in books or the environment</td>
</tr>
<tr>
<td>number spinner</td>
<td></td>
</tr>
</tbody>
</table>

*Note: The table above outlines various activities and experiences related to home number experiences and literacy experiences.*
**Early Number Skills**

<table>
<thead>
<tr>
<th>Cardinal Counting</th>
<th>Numeral Transcoding</th>
<th>Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Give me X</td>
<td>Counting Objects</td>
<td>Additions</td>
</tr>
<tr>
<td></td>
<td>Number Recognition</td>
<td>Subtractions</td>
</tr>
<tr>
<td></td>
<td>Numeral Reading</td>
<td></td>
</tr>
</tbody>
</table>

- Consistently associated with later mathematical attainment (see Jordan et al., 2007, 2009)
- CFA confirmed 3 factor structure at both time points
- Explained 44% of the variance of a standardised maths test at T₃
<table>
<thead>
<tr>
<th>Language</th>
<th>Nonverbal abilities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phonological awareness</strong></td>
<td><strong>Vocabulary</strong></td>
</tr>
<tr>
<td>Rhyme awareness</td>
<td>Receptive vocabulary</td>
</tr>
<tr>
<td>Alliteration awareness</td>
<td>Expressive Vocabulary</td>
</tr>
<tr>
<td></td>
<td>Big/little Stroop</td>
</tr>
<tr>
<td></td>
<td>Fish-shark</td>
</tr>
<tr>
<td></td>
<td>Matrices</td>
</tr>
<tr>
<td></td>
<td>Picture similarities</td>
</tr>
<tr>
<td><strong>Executive functioning</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Nonverbal reasoning</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

✓ CFA indicated a 2 factor structure best fit
1. A home learning model
   What home learning and demographic factors in preschool predict the early number skills at the end of Reception?

2. A language and cognitive model
   Do language and nonverbal abilities predict growth in the early skills from preschool to the end of Reception?

3. A combined model
   Do the home learning experiences predict growth in the early number skills directly or via their relationship with language skills?
A home learning model

- Postcode decile
- Parental qualification
- Number Experiences
- Letter-sound Interactions

Correlations:
- Counting $T_3$: 0.24
- Number transcoding $T_3$: 0.25
- Calculation $T_3$: 0.22

Spring Preschool
Summer Reception
A language and cognitive model

Counting $T_1$ — $0.25$ — Counting $T_3$

Number transcoding $T_1$ — $0.45$ — Non-Verbal

Language — $0.20$ — Calculation $T_3$

Language — $0.14$ — Number transcoding $T_3$

Calculation $T_1$ — $0.33$ — Spring Preschool

Spring Preschool — Summer Preschool — Summer Reception

Summer Preschool

Summer Reception
A combined model

- Letter & Sounds Interactions $T_1$
- Counting $T_1$
- Number transcoding $T_1$
- Calculation $T_1$
- Spring Preschool

- Non-Verbal
- Language

- Counting $T_3$
- Number transcoding $T_3$
- Calculation $T_3$
- Summer Reception

Correlations:
- 0.22
- 0.35
- 0.45
- 0.26
- 0.11
- 0.16
- 0.13
- 0.14
- 0.24
- 0.17
- 0.26
Conclusions

1. To what extent do preschool language and cognitive skills predict growth in early number skills?

• Language skills predict growth in counting, number transcoding and calculation
• Nonverbal cognitive skills have a more limited influence counting and number transcoding
Conclusions

2. To what extent do number-oriented and language and literacy-oriented aspects of the home learning environment predict growth in early number skills?

3. To what extent are the relationships between the quality of the home learning environment and early number skills direct and to what extent are they indirect via the promotion of language skills?
   - Only letter-sound interactions (an aspect of code-focused home literacy environment) predict early number skills
   - Letter-sound interactions have indirect relationships with all early number skills and a direct relationship with counting skills
     - Developing language
     - Developing symbolic understanding

Conservative models with control for autoregressive effects supports the argument that Letter-sound interactions have a supportive role (particularly for counting rather than merely being a correlate)
Implications

• Preschool language skills are important for the development of early number skills
  • Experiences that support the development of phonological and vocabulary abilities in preschool will support both the development of early number skills and emerging literacy
  • Age-appropriate experiences to promote phonological and vocabulary abilities support both literacy and numeracy
• Letter-sound interactions are likely to support phonological and alphabetic understanding
  • In turn this supports early number skills and emerging literacy
• Parents need support:
  • Ideas for age-appropriate, informal letter-sound interactions. How can they integrate discussions about letters and sounds into their child’s everyday experiences
  • Confidence in their alphabetic knowledge
Future directions

• Why is there no independent impact of number experiences?
  • Too infrequent to have an impact?
  • Too basic?
    • Relationships stronger with ‘advanced’ scales
    • Needs assessing controlling for autoregressive effects (cause or response)
• Assessing the impact of strategies to promote parental letter-sound interactions
  • Can we increase the frequency of these interactions?
  • Does it have an impact on children’s phonological awareness, alphabetic knowledge and early number skills?
• RCT gold standard
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74 Primary Schools

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Professor Gaia Scerif, University of Oxford

In memoriam
Dr Catherine Willis