Causal Path Analysis of Processes Affecting Early Reading.

A 2-year longitudinal study investigated the causal contributions of phonological processing to early reading competency. Subjects, 161 kindergarten children, were tested with a battery of measures assessing letter knowledge, reading ability, and 5 phonological constructs: rapid naming ability, rhyming ability, phonological memory (successive processing), phonological synthesis (blending), and phonological analysis. Of the subjects, 122 were administered measures of reading ability one year later in grade 1. Results indicated (1) the most successful model showed naming and memory abilities contributing toward the acquisition of letter knowledge and the development of rhyming ability, which in turn supported synthesis, which then contributed to analysis which had the only significant effect upon reading; (2) phonological analysis was the most salient predictor of grade 1 reading; and (3) the causal path was more plausibly from analysis to reading than from reading to analysis. Findings support two conclusions: phonological analysis is the most powerful cognitive variable determining early reading competency; and phonological analysis depends in turn upon earlier developing skills, including phonological synthesis, letter knowledge, and naming, memory, and rhyming abilities. (Four figures and three tables of data are attached.) (RS)
This paper reports the results of a 2-year longitudinal study investigating the causal contributions of phonological processing to early reading competency. 161 kindergarten children subjects were tested with a battery of measures assessing letter knowledge, reading ability, and five phonological constructs: rapid naming ability, rhyming ability, phonological memory (successive processing), phonological synthesis (blending), and phonological analysis. 122 of these subjects were readministered measures of reading ability one year later in Grade 1.

Results

Confirmatory factor analysis and structural equation modelling were employed to investigate a number of possible theory-based models of phonological processing and reading in the kindergarten and Grade 1 data separately. In kindergarten, the most successful model showed naming and memory abilities contributing toward the acquisition of letter knowledge and the development of rhyming ability, which in turn supported synthesis, which then contributed to analysis which had the only significant effect upon reading. In the Grade 1 data, the most successful model followed the same general structure, with fewer significant paths for naming, memory, and rhyming abilities.

The kindergarten data were then used to predict Grade 1 reading ability, in both structural equation modelling and regression analysis. These results indicated that phonological analysis was the most salient predictor of Grade 1 reading, and that the causal path was more plausibly from analysis to reading than from reading to analysis.

Implications and Conclusions

This study adds support to two conclusions: (a) phonological analysis is the most powerful cognitive variable determining early reading competency, and (b) phonological analysis depends in turn upon earlier developing skills, including phonological synthesis, letter knowledge, and naming, memory, and rhyming abilities. These findings have implications for early screening, diagnostic assessment, and instruction. They suggest that

1This research was supported by a grant from the Social Sciences and Humanities Research Council of Canada to John R. Kirby and J.P. Das. We thank J.P. Das, J.A. Naglieri, and R. Wagner for making tests available. Address requests for a complete paper to John R. Kirby, Education, Queen’s University, Kingston, Ontario, K7L 3N6.
Early assessment and intervention may help to eliminate many reading difficulties. Furthermore, because children with severe reading difficulties may have deficiencies in many of the components of phonological processing, phonological intervention may have to be quite broadly based.

<table>
<thead>
<tr>
<th>Construct</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Successive Processing</strong></td>
<td>Word Series (Das &amp; Naglieri, 1994) Serial recall of lists of words of increasing length.</td>
</tr>
<tr>
<td></td>
<td>Sentence Repetition/Questions (Das &amp; Naglieri, 1994) Recall of and answering questions about nonsense sentences.</td>
</tr>
<tr>
<td><strong>Phonological Analysis</strong></td>
<td>Phoneme Elision (Torgesen, Wagner, &amp; Rashotte, 1994) Pronunciation of a word after deletion of indicated phoneme.</td>
</tr>
<tr>
<td></td>
<td>Sound Isolation (Torgesen et al., 1994) Identification of initial, middle, or final sound in a given word.</td>
</tr>
<tr>
<td><strong>Phonological Synthesis</strong></td>
<td>Blending Onset and Rime (Torgesen et al., 1994) Pronunciation of words when given component onsets and rimes.</td>
</tr>
<tr>
<td></td>
<td>Blending Phonemes (Torgesen et al., 1994) Pronunciation of words when given component phonemes.</td>
</tr>
<tr>
<td><strong>Rhyming</strong></td>
<td>Nursery Rhyme Knowledge (adapted from Maclean et al., 1987) Recitation of all or part of 4 common rhymes.</td>
</tr>
<tr>
<td></td>
<td>Rhyme Production (Maclean et al., 1987) Production of a rhyming word or non-word in response to a given word.</td>
</tr>
<tr>
<td></td>
<td>Rhyme Oddity (Bradley &amp; Bryant, 1985). (Grade 1 only)</td>
</tr>
</tbody>
</table>
Rapid Naming

*Color Naming* (Wolf, Bally, & Morris, 1986). Timed naming of a sequence of colors.

*Picture Naming* (Wolf et al., 1986) Timed naming of a sequence of pictures.

Letter Knowledge


*Letter Sound* (Clay, 1992). Production of correct sounds for letters presented in upper case in random order. (Grade 1 only).

Reading


*Word Identification* (Woodcock, 1987) Pronunciation of words shown without context.
Kindergarten Structural Model

- Reading
  - Analysis
    - Synthesis
      - Letter Knowledge
        - Rapid Naming
          - Rhyming
            - Phonological Memory

- \( X^2 (54) = 66.2, p = .12 \)
- CFI = .99
Grade 1 Structural Model

Reading -> Analysis
Analysis -> Synthesis
Synthesis -> Letter Knowledge
Letter Knowledge -> Rhyming
Rhyming -> Phonological Memory

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$X^2 (80) = 140.26 \ p = .001$

CFI = .96 6
Kindergarten - Grade 1 Structural Model

Grade 1 Reading

Grade 1 Synthesis

K-Letter Knowledge

K-Phonological Memory

Grade 1 Analysis

K-Rhyming

K - Rapid Naming

\[ X^2 (59) = 75.76, p = .07 \]
\[ CFI = .98 \]
Analysis and Reading (K to 1)

K - Analysis → Grade 1 Analysis

K - Reading → Grade 1 Reading

K - Analysis → Grade 1 Analysis

K - Reading → Grade 1 Reading

$x^2 (11) = 31.1, p = .001$

CFI = .98
Summary of Regression Analyses
Predicting Grade 1 Reading from Kindergarten Phonological Measures

Dependent variable: Grade 1 Word Identification

\[ R^2 = .60, \ p < .0001 \]

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Standardized coefficient</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phoneme Elision (Analysis)</td>
<td>.34</td>
<td>.0001</td>
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<tr>
<td>Sound Isolation (Analysis)</td>
<td>.26</td>
<td>.006</td>
</tr>
<tr>
<td>Blending Phonemes (Synthesis)</td>
<td>.19</td>
<td>.03</td>
</tr>
<tr>
<td>Picture Naming (Naming)</td>
<td>-.17</td>
<td>.008</td>
</tr>
</tbody>
</table>

Dependent variable: Grade 1 Word Attack

\[ R^2 = .48, \ p < .0001 \]

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Standardized coefficient</th>
<th>p</th>
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<tbody>
<tr>
<td>Phoneme Elision (Analysis)</td>
<td>.25</td>
<td>.016</td>
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<tr>
<td>Sound Isolation (Analysis)</td>
<td>.41</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Sentence Repetition (Memory)</td>
<td>.15</td>
<td>.08</td>
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</table>
Correlations between phonological analysis and reading measures in kindergarten and Grade 1 (n = 122).

<table>
<thead>
<tr>
<th></th>
<th>Kindergarten Phoneme Elision</th>
<th>Kindergarten Sound Isolation</th>
<th>Kindergarten Word ID</th>
<th>Kindergarten Word Attack</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 1 Phoneme Elision</td>
<td>.63</td>
<td>.60</td>
<td>.52</td>
<td>.43</td>
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<tr>
<td>Grade 1 Sound Isolation</td>
<td>.54</td>
<td>.60</td>
<td>.46</td>
<td>.37</td>
</tr>
<tr>
<td>Grade 1 Word Identification</td>
<td>.69</td>
<td>.68</td>
<td>.90</td>
<td>.77</td>
</tr>
<tr>
<td>Grade 1 Word Attack</td>
<td>.61</td>
<td>.64</td>
<td>.83</td>
<td>.84</td>
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<tr>
<td>Author(s):</td>
<td>KIRBY, J. R., MARTINSEN, R., &amp; BEGGS, P.</td>
</tr>
</tbody>
</table>

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