Linguistic, Quantitative, and Executive Predictors of Learning Mathematics in a Second Language

Anne Lafay
Helena P. Osana
Sophie Lemieux
Marion Valat

Introduction

• In Quebec, Canada, almost 15% of bilingual children aged 10-14 may be instructed in a language that is not spoken at home (Statistics Canada, 2016).

• Are children learning mathematics in a second language disadvantaged, or does a second language create an enriched exposure to mathematical concepts? (Bialystok, 2009; Clarkson, 1992; Van Rinsveld et al., 2015).

Aims

• To understand how linguistic, quantitative, and executive precursors are implicated in second grade children’s mathematical development.

• To clarify how developmental numeracy pathways are affected when the language of instruction is different from the language used in the home to first expose children to numeracy concepts.

Framework

• Pathways Model of Numeracy Development (LeFevre et al., 2010) : three cognitive precursors (linguistic, quantitative, and executive factors)

Method

Context

• Language Learning and Mathematics Achievement (LLaMA) Project
• Collaboration with J.-A. LeFevre (Carleton University), S.-L. Skwarchuk (University of Winnipeg), J. Wylie (Queen’s University Belfast), and V. Simms (University of Ulster)

Participants

• Second-grade students (n = 81) in 6 francophone schools in Quebec, Canada
  • Unilingual francophone (n = 50) receiving mathematics instruction in French
  • Bi- or multilingual (n = 31); Home language: English (16 students), Other (15 students)

Table 1. Sample Descriptive Statistics

<table>
<thead>
<tr>
<th></th>
<th>Unilingual Children</th>
<th>Bilingual Children</th>
<th>t-test</th>
<th>( \chi^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age in months</td>
<td>95.0 (5.4)</td>
<td>95.7 (4.8)</td>
<td>Non significant</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>Male: 46%</td>
<td>Male: 35.5%</td>
<td>Non significant</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Female: 54%</td>
<td>Female: 64.5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family Income</td>
<td>Very low: 20%</td>
<td>Very low: 12%</td>
<td>Non significant</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low: 20%</td>
<td>Low: 22%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Medium: 15%</td>
<td>Medium: 11%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>High: 10%</td>
<td>High: 22%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Very high: 35%</td>
<td>Very high: 33%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Procedure

• Individual testing sessions (1 - 1.5 hours)
• Measures:
  • Outcomes: Number line estimation, arithmetic fluency, and word-problem solving
  • Measures: Cognitive Predictors
    • Linguistic: Vocabulary, reading
    • Executive: Verbal short-term and working memory, visuospatial short-term and working memory
    • Quantitative: Sublitzing
  • Symbolic Math Predictors
    • Linguistic & Quantitative: Math vocabulary
    • Quantitative: Number comparison

Results

Comparison (t-tests)

Table 2. Mathematics outcomes statistics

<table>
<thead>
<tr>
<th></th>
<th>Comparison</th>
<th>t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number line position</td>
<td>bilingual &gt; unilingual</td>
<td>.082</td>
</tr>
<tr>
<td>Arithmetic fluency</td>
<td>bilingual = unilingual</td>
<td>.220</td>
</tr>
<tr>
<td>Word-problem solving</td>
<td>bilingual = unilingual</td>
<td>.454</td>
</tr>
</tbody>
</table>

Prediction

• Math vocabulary is predictive in arithmetic fluency, regardless of language group.

• Math vocabulary is predictive in number line estimation and in word-problem solving in unilingual children.

Discussion

• Math vocabulary is predictive in arithmetic fluency, regardless of language group.

• Math vocabulary is predictive in number line estimation and in word-problem solving in unilingual children.

• Next steps:
  • To compare our pattern of results with those of Ottawa and Winnipeg
  • To establish developmental patterns by testing the same children one year later (2018-19)