Does the development of digital skills influence the development of basic numerical skills in children from three to four years old?

Line Vossius, Marie-Pascale Noël & Laurence Rousselle

University of Liège, Research unit on childhood
Catholic University of Louvain

Group of contacts - Tournai, May 2017
Part 1
Fingers

- Many studies show that gestures support verbal number knowledge (Di Luca & Pesenti, 2011; Goldin-Meadow, Levine & Jacobs, 2014; Roesch & Moeller, 2015)

- Cardinal number gestures: 2 contradictory studies
  - Nicoladis, Pika & Marentette (2010)
  - Gunderson, Speapen, Gibson & Goldin-Meadow (2015)
Does the digital performance impact the verbal performance in a task assessing the comprehension of cardinality between the age of three and four years old?
Experiment design

T1
N = 47
3 years 0 months
Verbal Tasks
Numerical Verbal Tasks
Cardinality
- Verbal « Give-a-number » task (Wynn, 1990; 1992)

T2
N = 60
3 years 4 months
Verbal Tasks
Digital Tasks

T3
N = 60
3 years 8 months
Verbal Tasks
Digital Tasks

T4
N = 60
4 years 0 months
Verbal Tasks
Cardinality
- Verbal « Give-a-number » task

T5
N = 47
4 years 4 months
Digital Tasks
Tasks assessing Cardinality understanding

Performances in «Give-a-number» task
Multi-level regressions

• Goal: using regressions at different levels to understand the implication of an independent variable on a dependent variable but, also taking into account the time and the interaction between the time and this independent variable.

• Equation:

\[
\text{« Dependant variable »} = \beta_{00} + \beta_{01}(\text{Initial state}) + \beta_{10}(\text{Time}) + \beta_{20}(\text{Independent variable}) + \beta_{30}(\text{Interaction}) + r_{0i} + e_{ti}
\]
Tasks assessing Cardinality understanding

« Give-a-number » tasks in digital and verbal modalities

« VGaN » = β₀₀ + β₀₁*(DGaN-T₂ₜ) + β₁₀*(TIMESₜ) + β₂₀*(DGaNₜ) + β₃₀*(TIMES*DGaNₜ) + r₀ᵢ + eᵢ

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>SE</th>
<th>t</th>
<th>p</th>
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</thead>
<tbody>
<tr>
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<td>0,09</td>
<td>0,63</td>
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<tr>
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<td>-1,51</td>
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<td>0,03</td>
<td>5,55</td>
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<td>Initial state</td>
<td>0,05</td>
<td>0,07</td>
<td>0,76</td>
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</table>

Evolution of performances in verbal “Give-a-number” task

Performances in digital task

1 2 3 4 5 6 7

3 3,4 3,8 4 4,4

Times
Tasks assessing Cardinality understanding

In «Give-a-number» task

- Digital performance plays a role in verbal performance, and this impact changes over time.

- The older the children are, the more verbal performance is impacted by digital performance on the same task.
Part 2
Digital gnosia were described as a good predictor of numeric and arithmetic performance (Fayol, Barrouillet, & Marinthe, 1998; Marinthe, Fayol, & Barrouillet, 2001; Noël, 2005).

Significant correlations were observed between manual dexterity and performance in addition tasks (Asakawa & Sugimura, 2009, 2011, 2014).

Lauzon (1990) split digital dexterity into 2 components: dissociation and coordination.
Does the development of digital skills influence the development of verbal numerical skills in children from three to four years old?
Experiment design

<table>
<thead>
<tr>
<th>T1</th>
<th>N = 47</th>
<th>3 years 0 months</th>
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<tbody>
<tr>
<td>Verbal Tasks</td>
<td>Digital Tasks</td>
<td>Non-numerical digital tasks</td>
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<table>
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<tr>
<th>T2</th>
<th>N = 60</th>
<th>3 years 4 months</th>
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<td>Non-numerical digital tasks</td>
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<table>
<thead>
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<th>N = 60</th>
<th>3 years 8 months</th>
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<td>Verbal Tasks</td>
<td>Digital Tasks</td>
<td>Non-numerical digital tasks</td>
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<table>
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<th>T4</th>
<th>N = 60</th>
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<td>Verbal Tasks</td>
<td>Digital Tasks</td>
<td>Non-numerical digital tasks</td>
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</tbody>
</table>

Non-numerical digital Tasks
- Digital gnosia task
- Imitations of digital configurations task
- Melokinetic praxia task
Impact of non-numerical digital skills

Impact of digital gnosia performances on verbal performances in «Give-a-number» task

\[ \text{VGaN} = \beta_{00} + \beta_{01} \times (DG-T2_i) + \beta_{10} \times (TIMES_{ti}) + \beta_{20} \times (DG_{ti}) + \beta_{30} \times (TIMES \times DG_{ti}) + r_{oi} + e_{ti} \]

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<td>29.66</td>
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<td>-1.19</td>
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<tr>
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<td>Interaction</td>
<td>0.03</td>
<td>0.02</td>
<td>1.73</td>
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<td>0.05</td>
<td>-0.72</td>
<td>.47</td>
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Impact of performances in digital gnosia task on performances in the verbal “Give a number” task

Performances in digital gnosia task

Performances in verbal “Give a number” task
Impact of non-numerical digital skills

Impact of digital imitation performances on verbal performances in «Give-a-number» task


\[ \text{VGaN} = \beta_{00} + \beta_{01}(\text{IDC-T2}) + \beta_{10}(\text{TIMES}_{ti}) + \beta_{20}(\text{IDC}_{ti}) + \beta_{30}(\text{TIMES*IDC}_{ti}) + r_{0i} + e_{ti} \]

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</thead>
<tbody>
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<td>30.49</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Times</td>
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<td>0.25</td>
<td>-0.14</td>
<td>0.89</td>
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<tr>
<td>Digital imitation performance</td>
<td>-0.09</td>
<td>0.04</td>
<td>-1.95</td>
<td>0.05</td>
</tr>
<tr>
<td>Interaction</td>
<td>0.05</td>
<td>0.02</td>
<td>3.28</td>
<td>0.001</td>
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<tr>
<td>Initial state</td>
<td>-0.03</td>
<td>0.03</td>
<td>-0.98</td>
<td>0.33</td>
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Performances in imitation of digital configurations task on performances in verbal «give-a-number» task
Impact of non-numerical digital skills

Impact of melokinetic praxia performances on verbal performances in «Give-a-number» task

\[ \text{VGA N} = \beta_{00} + \beta_{01} \times (MP-T2_i) + \beta_{10} \times (TIMES_{ti}) + \beta_{20} \times (MP_{ti}) + \beta_{30} \times (TIMES \times MP_{ti}) + r_{0i} + e_{ti} \]

<table>
<thead>
<tr>
<th>Effect</th>
<th>Coefficient</th>
<th>SE</th>
<th>t</th>
<th>p</th>
</tr>
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<tbody>
<tr>
<td>Intercept</td>
<td>2.99</td>
<td>0.1</td>
<td>30.97</td>
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<td>Times</td>
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<td>Digital gnosia performance</td>
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<td>-1.83</td>
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<tr>
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<td>3.81</td>
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<tr>
<td>Initial state</td>
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<td>0.07</td>
<td>-0.54</td>
<td>.59</td>
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</tbody>
</table>
Impact of non-numerical digital skills

• Digital gnosia performance has less impact on verbal give-a-number performance than components of dexterity, such as dissociation skills or coordination skills

• Dissociation skills and coordination skills

  • Over time, the more efficient children are at dissociating and coordinating their fingers, the more efficient they are at understanding cardinality in verbal modality.
Impact of non-numerical digital skills

Non-numerical digital performances → Numerical digital performances → Numerical verbal performances

Just marginally significant interaction between times and praxia performances
In conclusion

• Numerical digital performances play a role in the numerical verbal performances and this impact is modulated by the time

• Some non-numerical digital skills play a role in the verbal performance
  • Not digital gnosia skills
  • But dexterity skills (dissociation and coordination components)

• In general, the older the child is, the more this influence increases.
Future questions

Soon...

- Do numerical digital skills explain non-numerical digital skills?
- Is this pattern of results observed in other tasks known to assess the cardinality, such as equivalence judgement tasks in verbal and digital modalities?
- Is this pattern of results observed in numerical tasks associated with the comprehension of cardinality, such as function of succession tasks?
- ...

A little less soon...

- What is the impact of dissociation and coordination skills on performance in arithmetic?
- What is the impact of these digital skills in pathological populations?
- ...

Thanks a lot to Laurence Rousselle and Marie-Pascale Noël

Thank you for your attention!