# Finger-based and verbal cardinal representations in young children born pre-term

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## Introduction

Children born prematurely are at increased risk of developing learning difficulties in mathematics (McBryde et al., 2020; Lee et al. , 2017). They were found to show more or less persistent impairment in numerical skills involving the approximate number system (Clayton et al., 2022; Guarini et al., 2019), counting (Guarini et al., 2014; McBryde et al., 2020), or arithmetic (Clayton et al., 2022; McBryde et al., 2020).

It has been suggested that finger use support the development of counting skills, cardinal knowledge and arithmetic skills (Roesch & Moeller, 2015) and numerous studies provided evidence of the link between sensorimotor abilities and the development of basic numerical and arithmetic skills in preschool-aged children (Barrocas et al., 2020).

These learning difficulties may stem from the well-documented and persistent sensorimotor impairments in these children (Evensen et al., 2020; Lönnberg et al., 2018). Several recent studies have highlighted the links between fine sensorimotor skills and numerical development in children born preterm (Adrian et al., 2020; Clayton et al., 2022; Hasler & Akshoomoff, 2019). However, there is no consensus on the existence of these relationships (van Veen et al., 2019). Additionally, these studies often focus on very general measures of numerical development or academic achievement, and do not delve into specific dimensions of numerical cognition. Moreover, none of them specifically addresses cardinality.

## Aims

- Examining the development of verbal and finger-based cardinal representations in children born pre-term in relation with their motor impairment.
- Comparing the numerical mapping (no motor demand) and the production (motor demand) of finger-based cardinal representation to examine how motor requirements influence finger-based cardinal knowledge.

## Methodology

Sixty 3- to 5-year-old children :
- 30 born pre term (<37 weeks of gestation)
- 30 full-term age-matched control children (> 37 weeks of gestation, month-to-month matching)

### Descriptive Measures

- M-ABC –Manual dexterity index (money box, thread, visuo-motor precision)
- Verbal number sequence
- Advanced counting
- Counting

### Give-N tasks

- Material : 10 tokens
- 2 input modalities :
  - Verbal : Can you give me *[three]* tokens?
  - Number Gesture : Can you give me that ?
- Cardinal development level = the largest numerosity accurately given by the child two out of three trials

### Point-to-N tasks

- *Show me where there is...*
- 2 input modalities
  - Verbal : *[six]*
  - Cardinal Number Gesture :
- Output stimuli : 2 collections
- Numerosities : 1 to 10

### Show-me-N tasks

- *Show me [six]* (verbal input only)
- 2 output modalities :
  - **Mapping** with pictures of cardinal number gestures
  - **Production** of a cardinal number Gesture : show me *[six]* with your fingers
- Numerosities : 1 to 10

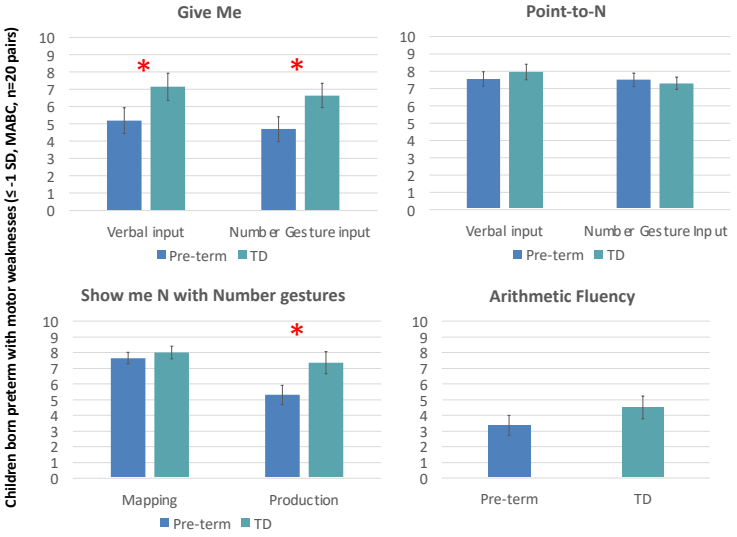
### Arithmetic fluency

- 10 verbal additive problems with pictorial support :

*There are 2 birds in this cage. If one other bird enters into the cage, how many birds will there be in total?*

- Measure: *n* of problems solved in 150 sec

## Results




Descriptive Statistics-all preterm children (n = 30 pairs)

| | | Pre-term Children | TD Children | Statistics (paired t-Test) | | |
|---|---|---|---|---|---|---|
| | N | Mean (SD) | Mean (SD) | t(29) | p | Effect Size |
| MABC-Dexterity | 30 | 6.4 (-2.37) | 7.9 (-3.34) | -2.11 | **0.04** | -0.39 |
| Give-me Verbal | 30 | 5.4 (-3.44) | 6.6 (-3.71) | -1.81 | *0.08* | -0.33 |
| Give-me Number Gesture | 30 | 5.2 (-3.39) | 6.3 (-3.23) | -1.71 | 0.10 | -0.31 |
| Point-to-N Verbal | 30 | 7.7 (-1.84) | 7.8 (-1.96) | -0.14 | 0.89 | -0.03 |
| Point-to-N Number Gesture | 30 | 7.5 (-1.59) | 7.7 (-1.6) | -0.62 | 0.54 | -0.11 |
| Show me N -Mapping | 30 | 7.8 (-1.63) | 8.1 (-1.8) | -0.75 | 0.46 | -0.14 |
| Show me N -Production | 30 | 5.8 (-2.9) | 7.1 (-3.01) | -2.37 | **0.03** | -0.43 |
| Arithmetic Fluency | 30 | 3.5 (-3.09) | 4.4 (-3.77) | -1.22 | 0.23 | -0.22 |

*Note.* For the Student t-test, effect size is given by Cohen's *d* .

Descriptive Statistics- Only preterm children with motor weaknesses (≤ -1 SD, MABC, n=20 pairs)

| | | Pre-term Children | TD Children | Statistics (paired t-Test) | | |
|---|---|---|---|---|---|---|
| | N | Mean (SD) | Mean (SD) | t(19) | p | Effect Size |
| MABC-Dexterity | 20 | 5.1(-1.71) | 7.4(-3.22) | -2.66 | **0.02** | -0.60 |
| Give-me Verbal | 20 | 5.2(-3.32) | 7.2(-3.51) | -2.18 | **0.04** | -0.49 |
| Give-me Number Gesture | 20 | 4.7(-3.2) | 6.7(-3.15) | -2.37 | **0.03** | -0.53 |
| Point-to-N Verbal | 20 | 7.6(-1.85) | 8.0(-2.01) | -0.61 | 0.55 | -0.14 |
| Point-to-N Number Gesture | 20 | 7.5(-1.73) | 7.3(-1.59) | 0.46 | 0.65 | 0.10 |
| Show me N -Mapping | 20 | 7.7(-1.63) | 8.0(-1.81) | -0.64 | 0.53 | -0.14 |
| Show me N -Production | 20 | 5.3(-2.74) | 7.4(-3.15) | -2.86 | **0.01** | -0.64 |
| Arithmetic Fluency | 20 | 3.4(-2.87) | 4.5(-3.25) | -1.21 | 0.24 | -0.27 |

*Note.* For the Student t-test, effect size is given by Cohen's *d* .

Partial correlation between manual dexterity and numerical tasks (controlling for chronological age)

| | Give-me Verbal | Give-me Number Gesture | Point-to-N Verbal | Point-to-N Number Gesture | Show me N Mapping | Show me N Production | Arithmetic Fluency |
|---|---|---|---|---|---|---|---|
| MABC-Dexterity | 0.14 | 0.21 | 0.06 | 0.17 | 0.17 | **0.30*** | 0.13 |

*Note.* * $p < .05$

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## Conclusion

Children born preterm with limited fine motor skills exhibit delays in cardinal knowledge development. Both verbal and finger-based cardinal representations are impacted by prematurity associated with lower fine motor skills.

Moreover, fine motor skills correlate with the ability to produce number gestures corresponding to verbal number words, which has also been found to be impaired in preterm children.

In contrast, these children do not have difficulty mapping number words to number gestures, suggesting that their difficulties are specifically related to limited manual dexterity.

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