Numerical abilities in the deaf child, the role of language and short-term memory .

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Background

- ✓ Research on numerical abilities in deaf children (DC) is scarce and results are contradictory.
- ✓ The education type, the presence of cochlear implants, the language level or short-term memory (STM) skills, have been put forward as explanatory factors for differences in mathematics between DC and hearing children (HC).

The aims of the present study

- ✓ To investigate the development of **formal numerical abilities** in young DC with cochlear implants, **following regular education**.
- ✓ To clarify the link between **formal numerical abilities** and other related **cognitive factors** (as language and verbal STM), while controlling for education, age, gender and non-verbal cognitive level.

Methodology

✓ Participants

- 23 DC & 23 HC attended the same mainstream schools in Belgium or France.
- They are matched for age, sex and non-verbal ability (*Matrix* [a]).
- Other cognitive abilities, as language (*Peabody* [b]) and verbal STM [c] were assessed as well.

Means (SD) with group comparison test parameters are reported below:

Characteristics	DC	HC	Statistical analyses	
Chronological age in years	9.1 (1.9)	9.1 (1.7)	$t(44) = .07$	$p = .941$
Matrix subtest [a], T score	53.2 (8.8)	53.2 (6.6)	$t(44) = .00$	$p = 1.000$
Language *(Peabody [b])*, raw score	86.6 (23.5)	114.5 (27.5)	$t(44) = -3.70$	***p* =.001**
Verbal STM [c]	6.74 (2.0)	8.0 (2.2)	$t(44) = -2.05$	***p* =.047**

[a] Matrix subtest, Wechsler and Naglieri (2009).
[b] Peabody, Dunn et al. (1993).
[c] Digit span forward, Wechsler (2005).

✓ Measures

Formal numerical abilities

- Counting aloud [d] (as far as possible, from x, from x to y, backwards and by steps).
- Reading numbers aloud [d] (3 'single-digit', 9 'two-digits' & 8 'three-digits' numbers).
- Writing numbers to dictation [d] (3 'single-digit', 9 'two-digits' & 8 'three-digits' numbers).
- Number fact tests [e] (+ and - subtests, 1 min per condition).

Success rate, means (SD) with group comparison test parameters are reported below:

Formal numerical abilities	DC	HC	Statistical analyses	
Counting [e] (success rate)	47.8 %	73.9 %	χ^2 (1) = 3,29	$p = .070$
Reading numbers (success rate)	60.9 %	82.6 %	χ^2 (1) = 2,68	$p = .102$
Writing numbers (success rate)	47.8 %	82.6 %	χ^2 (1) = 6,13	***p* = .013**
+ Number fact [e] (total/min)	14.8 (7.0)	19.0 (7.4)	$t(44) = -1.97$	$p = .055$
- Number fact [e] (total/min)	11.8 (5.8)	15.4 (7.9)	$t(44) = -1.72$	$p = .093$

[d] Counting tasks, Van Nieuwenhoven et al. (2008).
[e] Tempo Test Rekenen (TTR), De Vos (1992).

Results

Counting
- Language: $W(1) = 4.61$, ***p* = .022**
- STM: $W(1) = 5.28$, ***p* = .032**
- Group: $W(1) = .07$, $p = .789$

Reading numbers
- Language: $W(1) = 3.68$, ***p* = .055**
- STM: $W(1) = 4.99$, ***p* = .025**
- Group: $W(1) = .01$, $p = .907$

Writing numbers
- Language: $W(1) = 3.12$, $p = .077$
- STM: $W(1) = 3.52$, $p = .061$
- Group: $W(1) = .84$, $p = .358$

Wald test logistic regression : Regarding *counting* and *reading numbers abilities*, the variables language and STM are significant as they add some incremental value to the model.
On the contrary, the group fails to add value and do not affect the model in any meaningful way.
Regarding *writing numbers*, the 3 variables (language, STM & group) share common variance. Although each effect is not significant any more in the presence of the others, note that language and STM are close to the threshold.

+ Number fact
- Language: $F(1) = 27.45$, ***p* > .001**
- STM: $F(1) = 13.82$, ***p* = .001**
- Group: $ps > .301$

- Number fact
- Language: $F(1) = 31.88$, ***p* > .001**
- STM: $F(1) = 11.74$, ***p* = .001**
- Group: $ps > .408$

ANCOVA : When language and STM are introduced as covariates, the group effect disappears. These two variables predict the scores on the two *number fact tests*.

Conclusion

- ✓ This study demonstrates that, when DC and HC are **well paired for age, sex, non-verbal abilities**, as well as for **education type :**
- No association or difference are found between **groups of children** (DC versus HC) and **formal numerical abilities,** except for writing numbers. Further analysis should be conducted to determine the origin of this difference between DC and HC.
- **Language** and **STM** can predict a child's score for those formal numerical abilities.
- These data must be taken into account when caring for and educating deaf children.

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