A cognitive characterization of math impairments in children with 22q11.2 deletion syndrome

De Smedt, Bert[1], Devriendt, Koen[2], Fryns, Jean-Pierre[2], Verschaffel, Lieven[3], Ghesquière, Pol[1], & Swillen, Ann[2,4]

[1] Centre for Child Welfare, Parenting and Disabilities, University of Leuven, Belgium.
[2] Centre for Human Genetics, University of Leuven, Belgium.
[3] Centre for Instructional Psychology and Technology, University of Leuven, Belgium.
[4] Department of Rehabilitation Sciences, University of Leuven, Belgium.

INTRODUCTION

It has been consistently demonstrated that children with 22q11.2 deletion syndrome (22q11DS) have mathematics difficulties (MD), compared to relatively normal reading and spelling achievement (De Smedt et al., 2006). However, these studies were mostly restricted to the assessment of general standardized achievement tests and did not provide information about the strengths and weaknesses of children with 22q11DS within the broad multidimensional domain of mathematics. Therefore, we aimed to delineate more carefully the math impairment in primary school children with 22q11DS (age range 6 – 12 years) and compared their performance with that of an individually matched control group.

METHOD

PARTICIPANTS:

	N	Age	IQ
22q11DS	25 (♀ = 11)	9.8	93.5
Controls	25 (♀ = 12)	9.2	107.9

- All children had normal intellectual abilities (IQ > 70).
- Controls were selected from the same class within the same school.
- Both groups were of equal socioeconomic status.

MATERIALS:

Number processing	Number reading, Number writing, Number comparison
Counting	Verbal counting, Dot counting
Single-digit arithmetic[a]	Addition, Subtraction, Multiplication
Multidigit arithmetic	Addition, Subtraction
Word problems	Word problem solving

Note. Number domain 1 to 100. Accuracy and response times were registered per trial. [a]Strategy use was also recorded.

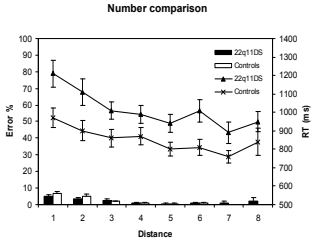
ANALYSIS: Group differences were evaluated by means of mixed models to account for the clustered nature of the data (matched pairs). We also analyzed the data at the individual level to determine on which math variable a particular child did show abnormal performance, i.e. 1.65*SD* below the control group mean (Pc 5). All analyses were controlled for age and IQ.

RESULTS

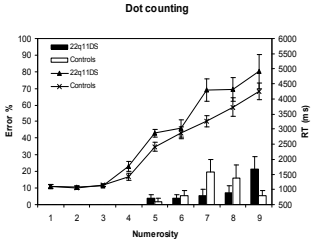
Analyses at the individual level revealed that 19/25 children with 22q11DS performed abnormally on at least one math task, which provides significant (p<.01) evidence for MD in 22q11DS.

NUMBER READING AND WRITING

Accuracy was high (> 99%). There were no group differences in the speed of reading numbers. This indicates that subsequent group differences are not due to a slower or less accurate number identification.



Mean (SE) error rates and RTs calculated for each distance.



Mean (SE) error rates and RTs calculated for each numerosity.

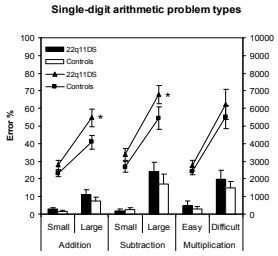
NUMBER COMPARISON:

- Children with 22q11DS were significantly slower (p < .05).
- A significant number of children with 22q11DS (10/25) performed abnormally.

DOT COUNTING: Children with 22q11DS were significantly slower (p < .05).

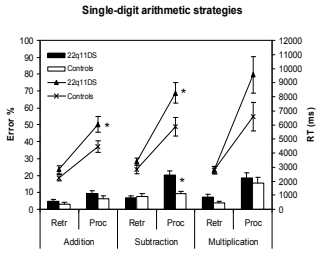
VERBAL COUNTING: No group differences, but large individual variability.

SINGLE-DIGIT ARITMETIC



Mean (SE) error rates and RTs per problem type.

* Significant group x problem type interaction (p < .05).



Mean (SE) error rates and RTs per strategy.
Retr = Retrieval. Proc = Procedural (calculation + counting).
* Significant group x strategy interaction (p < .05).

MULTIDIGIT ARITHMETIC - WORD PROBLEM SOLVING

	Accuracy		Speed	
	22q11DS	Controls	22q11DS	Controls
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Multidigit arithmetic	70.5 (20.6)**	83.2 (15.1)	9.3 (5.0)	7.9 (2.3)
Word problems	52.0 (29.4)**	70.0 (25.2)	7.7 (2.8)	5.4 (2.2)

Note. Accuracy is expressed in % correct. Speed is expressed in seconds. ** p < .01.

DISCUSSION

- Children with 22q11DS showed preserved number reading and fact retrieval. These children were significantly slower in number comparison and dot counting, pointing to difficulties in low-level number processing (Landerl et al., 2004). They also performed more poorly on executing procedural strategies and multidigit arithmetic, which might indicate that these children have some kind of *procedural* MD (Geary, 2004).

- A follow-up study on the same sample showed that children with 22q11DS did not differ from controls on working memory, speed of retrieving information from long-term memory, processing speed and reading; none of these general cognitive skills was related to math in children with 22q11DS (De Smedt et al., 2008a).

- It has been proposed that MD emerge due to impairments in basic number processing (Landerl et al., 2004). Our data showed that children with 22q11DS have difficulties in number comparison. Morever, number comparison emerged as significant and unique predictor of the MD in 22q11DS (De Smedt et al., 2008b). This indicates that the MD in 22q11DS are due to a specific deficit in the representation of quantities, which suggests underlying abnormalities in the intraparietal sulcus and fits the inferior parietal abnormalities reported in 22q11DS.

- Our data stress the need for early interventions that foster the development of representations of quantities in children with 22q11DS, as typically developing children acquire these skills already before formal instruction and these are not explicitly taught at school.

Selected References

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Contact: Bert De Smedt: e-mail Bert.DeSmedt@ped.kuleuven.be