How does the visuo-spatial deficit impact basic numerical processing in Williams syndrome? The question of domain specificity

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Williams Syndrome : cognitive profile

Known to be highly unequal:

- IQ~60 : majority of mild mental retardation [low average to severe MR]
- VIQ > NvIQ
- Relatively spared langage
- Relatively spared face processing but still peculiarities
- Deficient visuo-spatial capacities : Local > global processing
- Academic cursus : slight evolution in reading and spelling until adult age
- Rapid stagnation of math development from adolescence (Udwin et al., 1996)

About math development…

- Verbal number sequence can be retained but remains inflexible
  Paterson et al. (2006)
- Counting procedure **OK** (overlearned, H*ow many, Give me n*
  *(*Ansari et al. (2003)
- Single digit Arabic number reading **OK** in WS adults (Ansari et al., 2007)
  but multi-digit Arabic number reading < Down syndrome
  (Paterson et al., 2006)
- Some WS adults **OK** to check one-digit additions and multiplications
- Better performance for small calculations learned by root
  (Krajcsi et al., 2009)

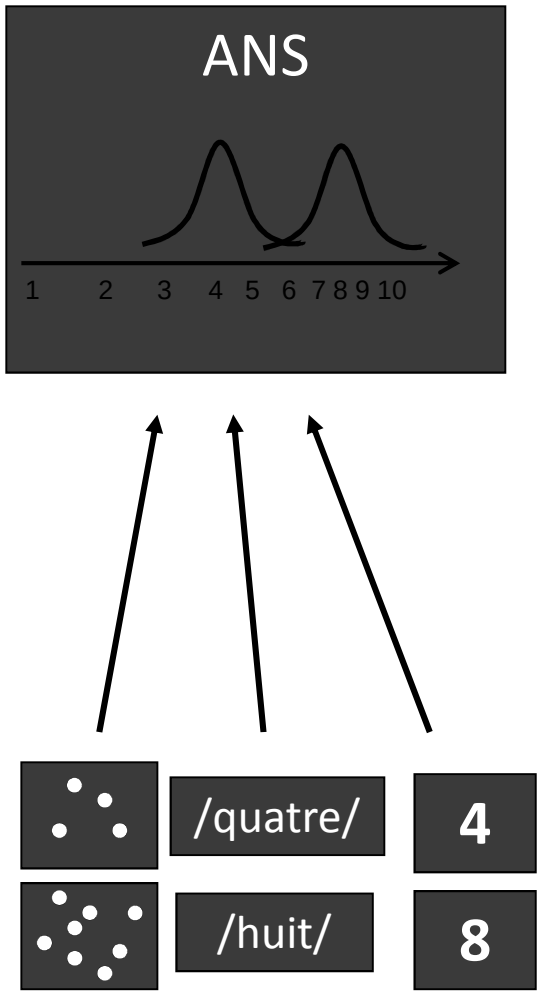
These studies :

➡ Information about the *nature* of the difficulties experienced quite late in the development

➡ But no information about the *origins* of these difficulties, about basic numerical processing
(= foundation of math competence)

Basic numerical processing?

Early sensitivity to numerosities : ≅ Approximate Number System



- ↗ imprecision with the nb of elements to quantify:
  - Size, Distance and Ratio effects
  - Weber fraction : Smallest numerical change to a stimulus that can be reliably detected
    => "numerical acuity" (Halberda & Feigenson, 2008)
- Innate/precocious : Independent of learning
- Basis of subsequent math learning

ANS in WS

- Young WS children (CA = 35 months; DA = 22 months) :

  Difficulty to detect the difference between collections of 8 vs 16 dots (Van Herwegen et al., 2008)

- Older WS children and adults (CA = 20 y-old [10-32 y] ; MA = 6;9 y [5-9y])

  Difficulty to determine which collections has more dots
  % children of the same MA (Paterson et al., 2006)

Deficit of the ANS in WS?

➡ Premature …

→Only tested with visual quantities involving processing the stimuli position in space

But, WS have important visuo-spatial difficulties

➡ How do they process quantities in tasks with no visuo-spatial processing requirement?

Study : Quantitative processing in WS

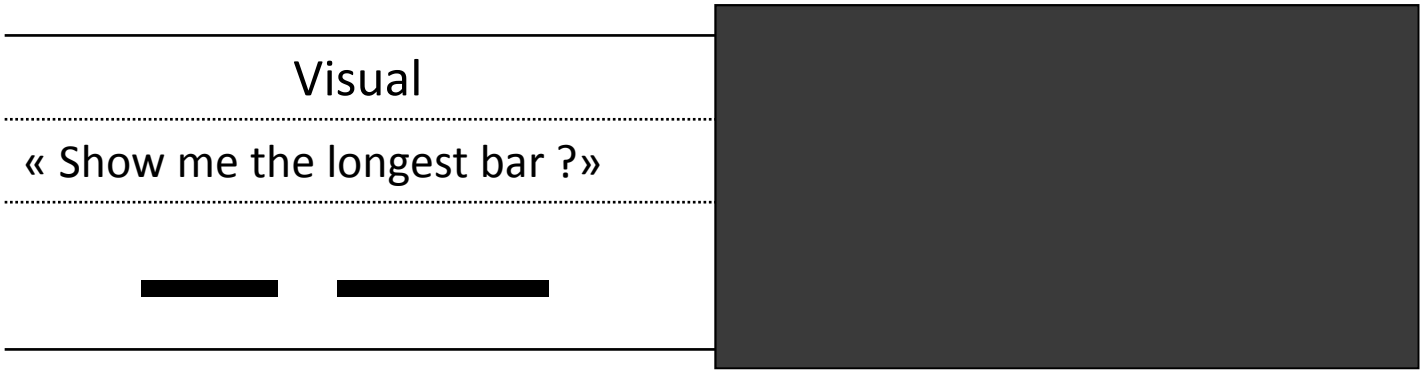
- Impact of visuo-spatial deficit on quantitative processing : 2 types :
  - Continuous/ Non numerical → Experiment 1
  - Discrete / non symbolic numerical → Experiment 2
- The focus on continuous quantitative processing? :

Walsh (2003) : central magnitude system for the processing of time, space and number magnitude information.

Simon (2008, 22q11 deletion syndrome) : Spatiotemporal processing form the basis of numerical and mathematical competence: Spatiotemporal processing deficit create "*suboptimal foundation for the subsequent development of numerical and mathematical competence, thereby ''cascading'' impairments into those more academic domains*"

XP 1 : Continuous quantities

- 20 SW & 20 TD children matched on verbal MA
- 2 tasks:

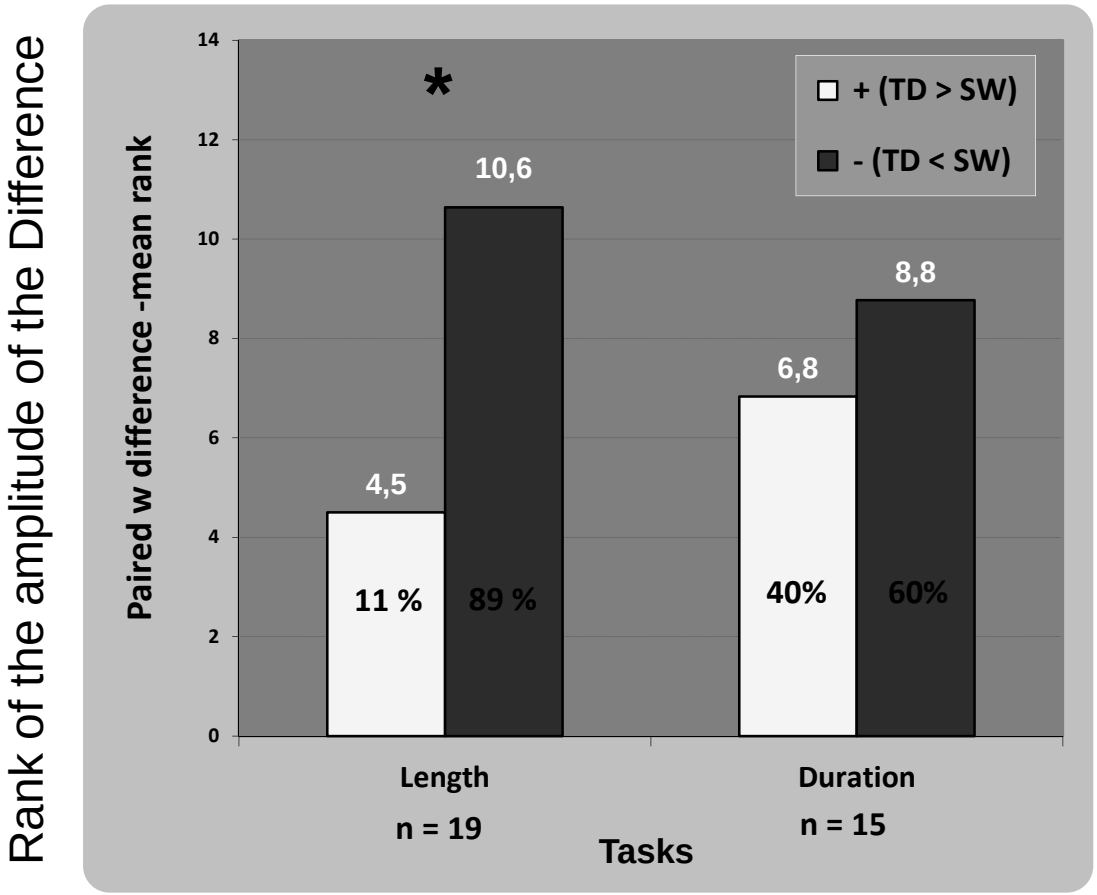


- Ratio of increasing difficulty = > Weber fraction

1/2	2/3	3/4	5/6	7/8	8/9

- Hypothesis :
  - If difficulty to process continuous quantities, then WS patients should have weaker performance in both tasks
  - If their visuo-spatial deficit interferes with visual quantitative processing, they should be impaired in the visual modality only.

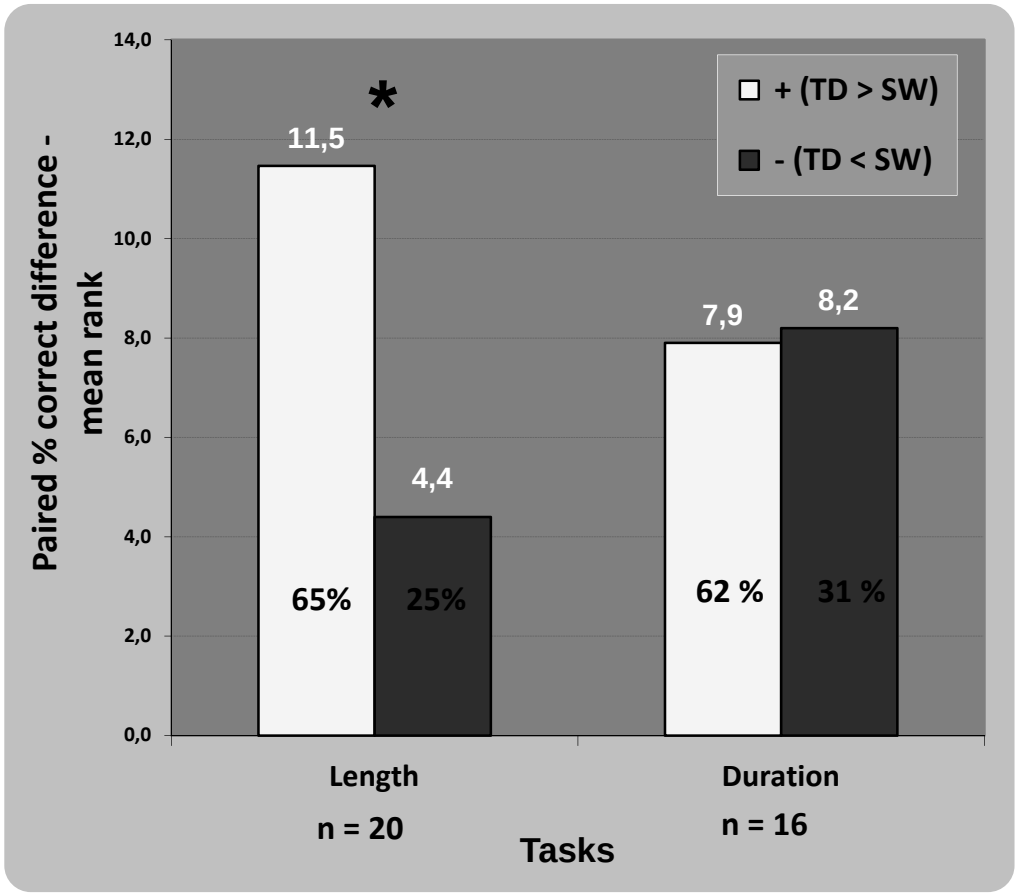
XP 1 : Continuous quantities : Weber fraction



Wilcoxon: Group effects :

- Length : p = .001
- Duration : p > .10

XP 1 : Continuous quantities : % correct responses



Wilcoxon: Group effects

(ratio 7/8)

- Length : p = .02
- Duration : p > .10

XP 2 : Non symbolic numerical quantities

- 20 SW & 20 TD children matched on verbal MA
- 2 conditions:

Spatial

«Who has more pieces of puzzle?»

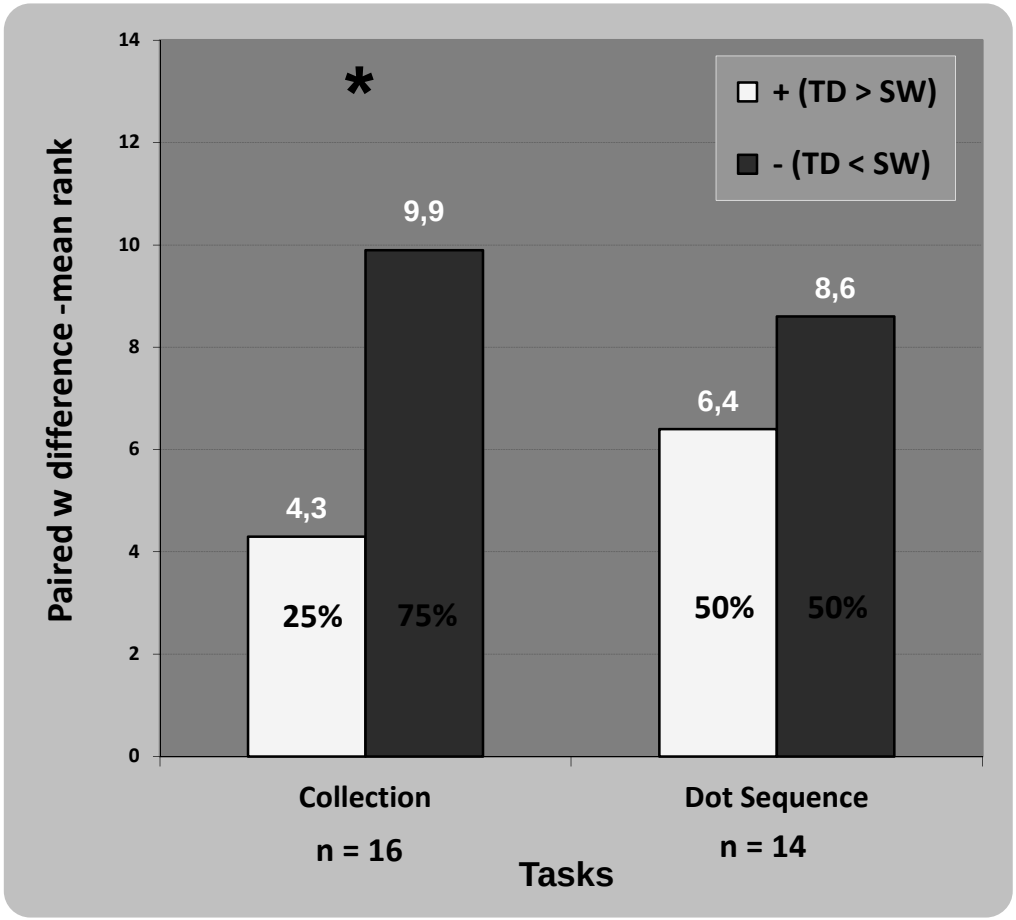
2 sec

- Ratio of increasing difficulty

1/2	2/3	3/4	5/6	7/8	8/9

- Hypothesis :
  - If difficulty to process non symbolic numerical quantities, WS patients should have weaker performance in both tasks
  - If their visuo-spatial deficit interfere with visual quantitative processing, they should be impaired in the spatial condition only.

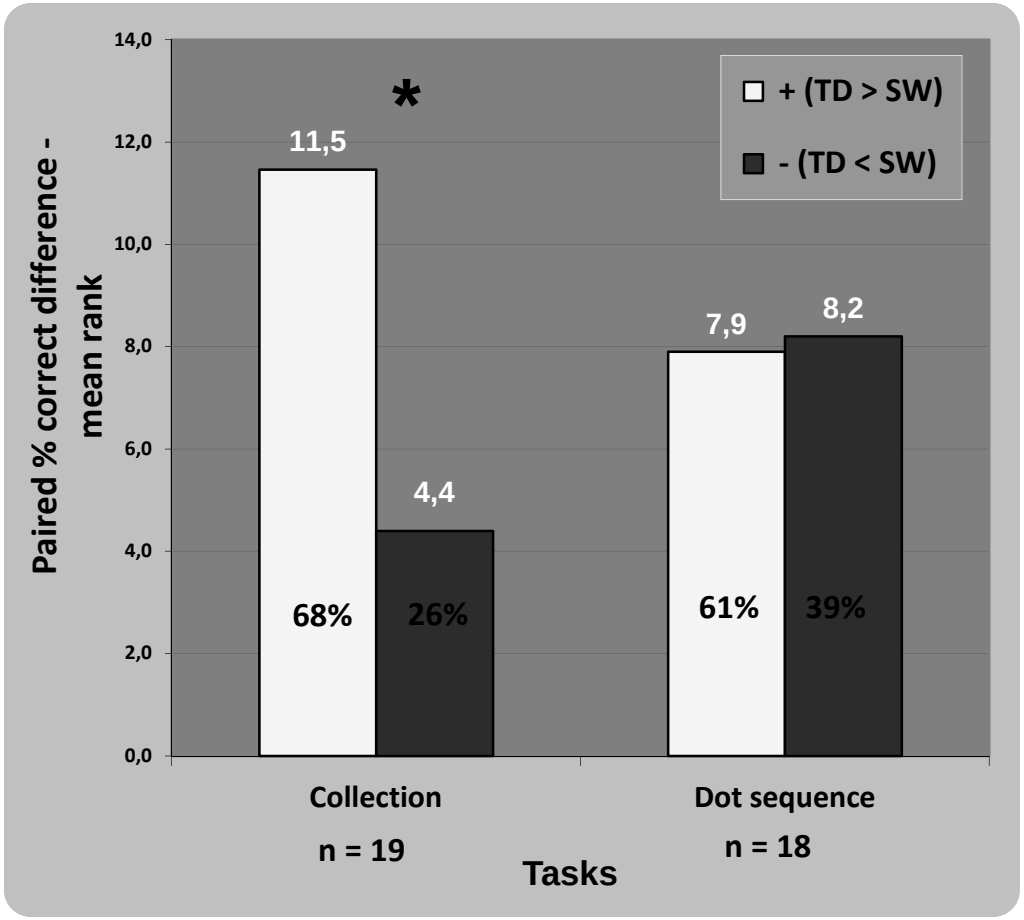
XP 2 : Non symbolic numerical quantities : Weber Fraction



Wilcoxon: Group effects :

- Collection : p = .008
- Dot sequence : p > .10

XP 2 : Non symbolic numerical quantities : % correct responses



Wilcoxon: Group effects

(ratio 3/4)

- Collection: p = .03
- Dot sequence : p > .10

Conclusion

SW patients :

- Difficulty to process numerical and non numerical quantities involving visuo-spatial processing
- Much less difficulty to process numerical and non numerical quantities distributed in time, and thus involving no visuo-spatial processing

=> WS difficulties in quantitative processing task are not domain specific.

Thank you for your attention

Leuven, February 2012

Math Development

- Verbal number sequence can be retained but remains inflexible
  - Difficulty to count between 2 numbers (25 to 35)
  - Difficulty to count backwards (20 to 1)
  - Difficulty to give the number coming *after n*

  } % Down syndrome (same MA et CA)

  Paterson et al. (2006)

- Counting procedure **OK** : (overlearned)
  - *How many*
  - *Give me n*

  } = children matched on visuo-spatial MA

  Ansari et al. (2003)

r3

Math Development

- Transcoding :
  - Single digit Arabic number reading **OK** in adults (Ansari et al., 2007)
  - But multi-digit Arabic number reading < Down syndrome of the same MA et CA (Paterson et al., 2006)

- Arithmetic :
  - Some WS adults **OK** to check one-digit additions and multiplications
  - Better performance for small calculations learned by root

    (Krajcsi et al., 2009)

Diapositive 18

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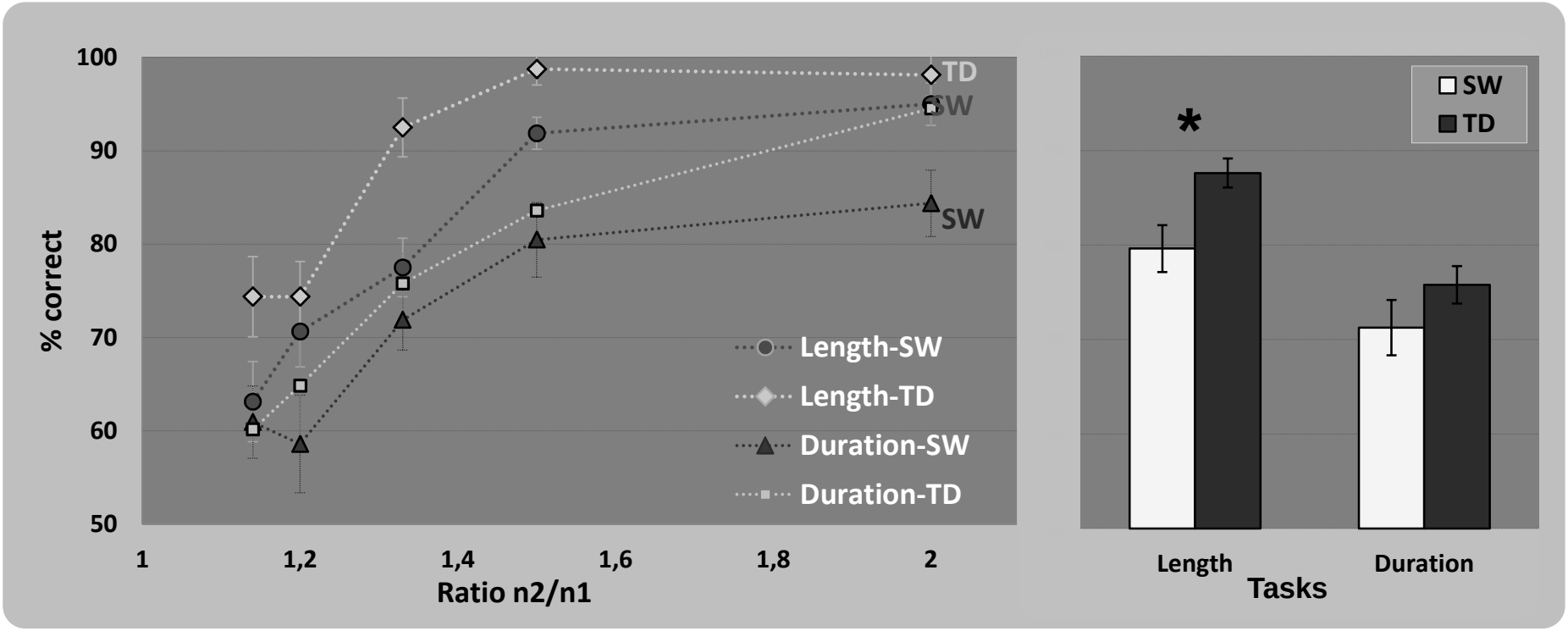
XP 1 : Continuous quantities : Correct responses



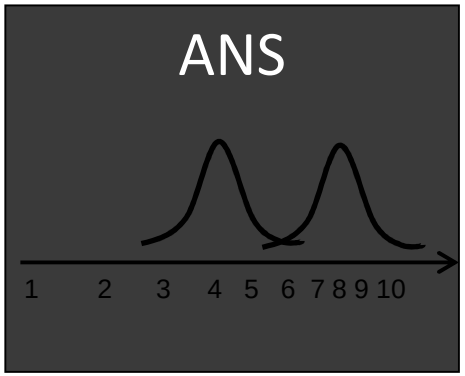
Mann-Whitney: Group effects (ratio 7/8):

- Length : N = 20 : p = .02
- Duration : N = 16 : p > .10

Study 2 : Symbolic numerical processing

- Association symbol ------ quantity
  - Difficult step for dyscalculic children
  - Also difficult for WS patients

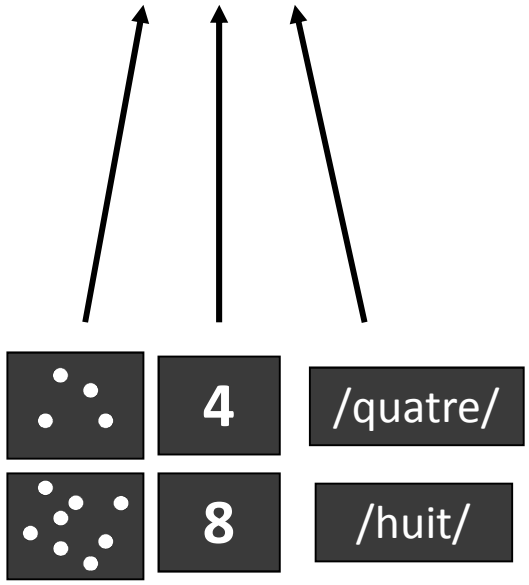
  (Paterson et al., 2006 ; Ansari et al. 2007 ; Krajsci et al., 2009)



Ex : SW < TD children matched on MA (O'Hearn & Landau, 2007) :

7

4 **9**



But ! Only tested Arabic number symbols (visual decoding)

Study 2 : Symbolic numerical processing

- 17 SW & 17 TD children matched on verbal MA
- 2 tasks:

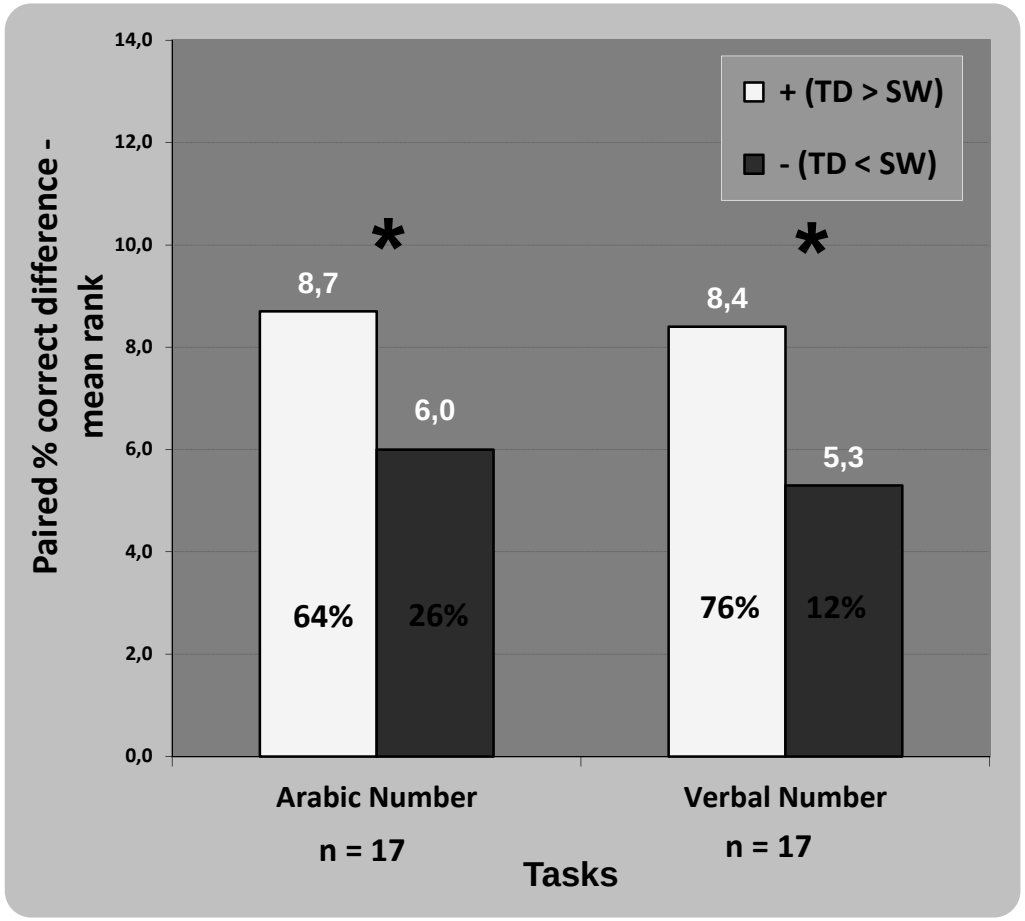
Visual

« Which number is the larger ?»

6 9

- Hypothesis :
  - Si difficulty to associate a symbol to its quantitative meaning, then WS patients should have weaker performance in both tasks.
  - If their visuo-spatial deficit interfere with visual symbolic processing, they should be impaired in the visual comparison task only.

Study 2 : Symbolic numerical processing



Wilcoxon: Group effects

(ratio 3/4)

- Arabic number: $p < .05$
- Verbal number: $p < .01$