

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



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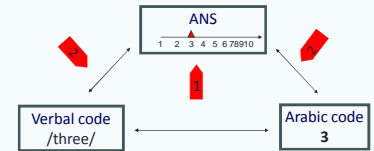
Introduction

Recent studies suggested that mathematics learning disabilities could result from a basic impairment of the Approximate Number System (ANS, Piazza et al., 2010,) or from a difficulty to connect symbolic numbers to their quantitative meaning (Rousselle & Noël, 2007,).

In Williams syndrome (WS), recent studies report specific deficits in tasks requiring symbolic and non symbolic numerical magnitude processing (Ansari et al., 2007; Krajcsi et al., 2009; O'Hearn & Landau, 2007; Paterson et al., 2006; Van Herwegen et al., 2008), supporting the view of a global deficit affecting the approximate numerical representations (ANS). However, basic numerical processing deficit in WS were always tested in the visual modality. Accordingly, it is not possible to know whether their impairment in numerical processing tasks would result from a basic dysfunction of the ANS or from their visuo-spatial impairment (i.e. a main characteristic of the cognitive phenotype of WS).

Moreover, several authors argued that our sensitivity to numerical magnitudes is rooted in our ability to process non-numerical magnitudes, in particular the spatial and the temporal dimensions (Walsh, 2003; Bueti & Walsh, 2009; Simon 2008). In WS, the processing of continuous non numerical quantitative processing has never been examined.

Aim: Examining non numerical and numerical magnitude processing with and without visual and/or spatial processing requirement in Williams syndrome.



Method

Participants :

- 20 participants with WS : chronological age (CA)= 22; 1 y-o [5;5 – 52;10]
 - 20 verbal-matched typically developing children (TDv): CA= 7; 6 y-o [4;6-11;8]
 - 20 nonverbal-matched typically developing children (TDnv): CA= 6; 0 y-o [3;11-10;4]
- ⇒ WS < TDv on non verbal developmental age, visuo-spatial abilities and math abilities

Tasks :

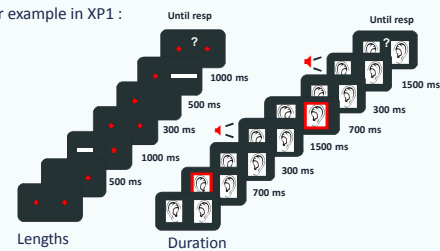
- non numerical quantities (XP1)
 - numerosities (XP2)
 - numerical symbols (XP3)
- In conditions with and without visuo-spatial processing requirement

Stimuli :

	Visual and/or spatial processing		No spatial processing	
	Lengths	Durations	Sequences of flashed dots	Verbal Numbers
XP1 : Non numerical quantities	Simultaneous Collections	Sequences of flashed dots	Sequences of flashed dots	Verbal Numbers
XP2 : Non symbolic numerical quantities	Controlling for : ▶ Cumulative surface area and perimeter ▶ External perimeter			Verbal Numbers
XP3 : Symbolic numerical quantities	Arabic numbers			Verbal Numbers
	12 16			12 /douze/ 16 /seize/

In XP1 and XP3, the visual stimuli were always presented sequentially, the first one on the left side of the screen, and the second one on the right side, in order to equilibrate the working memory load with the auditory condition.

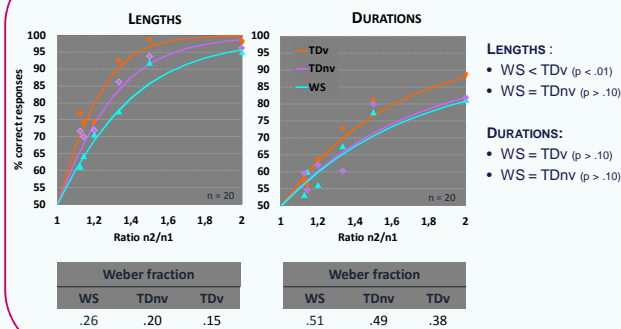
For example in XP1 :



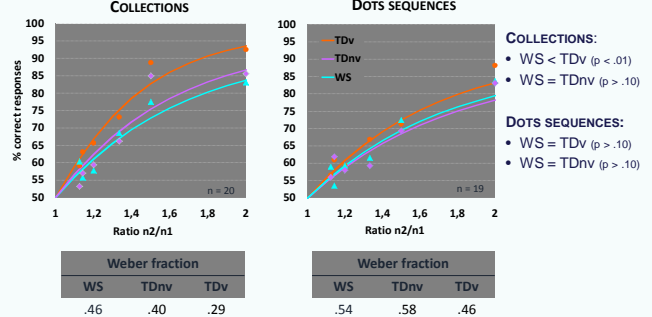
Ratio between quantities											
1/2	2/3	3/4	5/6	7/8	8/9						
7	14	6	9	6	8	5	6	7	8	8	9
8	16	10	15	12	16	10	12	14	16	16	18

Results

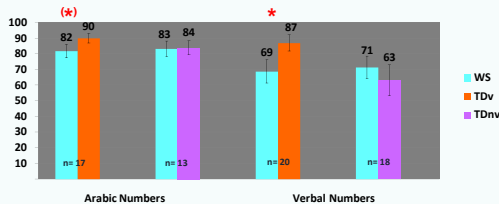
XP1 : Non numerical quantities



XP2 : Non symbolic numerical quantities



XP3 : Symbolic numerical quantities



In Summary

- ▶ Participants with WS show a consistent pattern of impairment in quantitative tasks requiring the processing of visuo-spatial dimension(s) (i.e. comparison of lengths or collections) but not in a visual task requiring processing numerosities with no spatial processing component (i.e. numerical comparison of sequences of flashed dots)
- ▶ They present difficulties to access the approximate number meaning (ANS) from numerical symbols as attested by their deficit in both symbolic numerical processing tasks.

References

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