On the importance to consider sequential presentation in magnitude processing for mathematical ability: evidence from Turner syndrome

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Introduction

Turner syndrome is a genetic condition characterized by a cognitive profile with a relative weakness in visuo-spatial abilities and preserved verbal abilities. They showed a severe impairment in mathematical abilities explained by a possible core deficit of numerosity processing (Simon et al., 2008). However, most of these processes are visual by nature and visual perception and numerical magnitude processing are often confounded in current studies.

Aim

The aim of this study was to **specify the influence of visuo-spatial processing on numerical abilities** by contrasting a series of tasks with different visuo-spatial processing requirement (auditory/low visuo-spatial/high visuo-spatial information) and different kind of magnitude processing (continuous/discrete for non-symbolic stimuli).
This was explored in female participants with Turner syndrome presenting a specific cognitive profile with low math and low spatial skills compared with control participants matched for verbal IQ, age and education.

Methods

Participants :

20 adults with Turner syndrome (TS) (219.2 ± 87.1) matched with 20 typically developing adults (C) (219.7 ± 91.75) on age, education and verbal IQ (Vocabulary and Similarities tests from WAIS-III)

→ Turner Syndrome ≠ Control participants on :

- Block design subtest (WAIS-III)
- Single-digit multiplication arithmetic fluencies (e.g. 3x4=?)
- Complex problem solving (two-digits numbers; problems mixed)

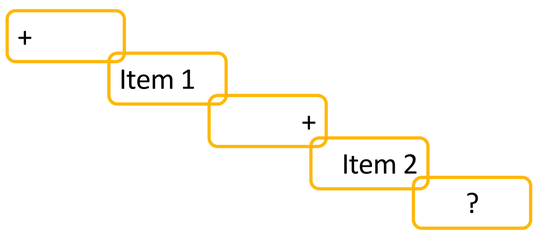
Tasks :

	Non-symbolic continuous quantities	Non-symbolic discrete quantities
Auditory	Durations	Sequences of sounds 
Visuo-spatial-Low	Lenghts	Sequences of flashed dots 
Visuo-spatial-High	/	Collections 

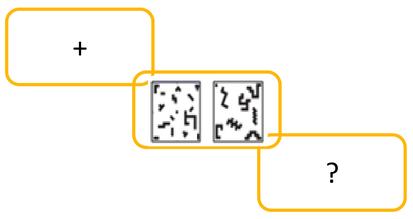
Controlling for :
- Cumulative surface area and perimeter of pieces
- External perimeter

Presentation : **All** tasks were presented **sequentially** excepted for collection comparison task

Sequential presentation



Simultaneous presentation



Ratio between numerosities :

	Ratios					
	1/2	2/3	3/4	5/6	7/8	8/9
Small	7-14	6-9	6-8	5-6	7-8	8-9
Large	8-16	10-15	12-16	10-12	14-16	16-18

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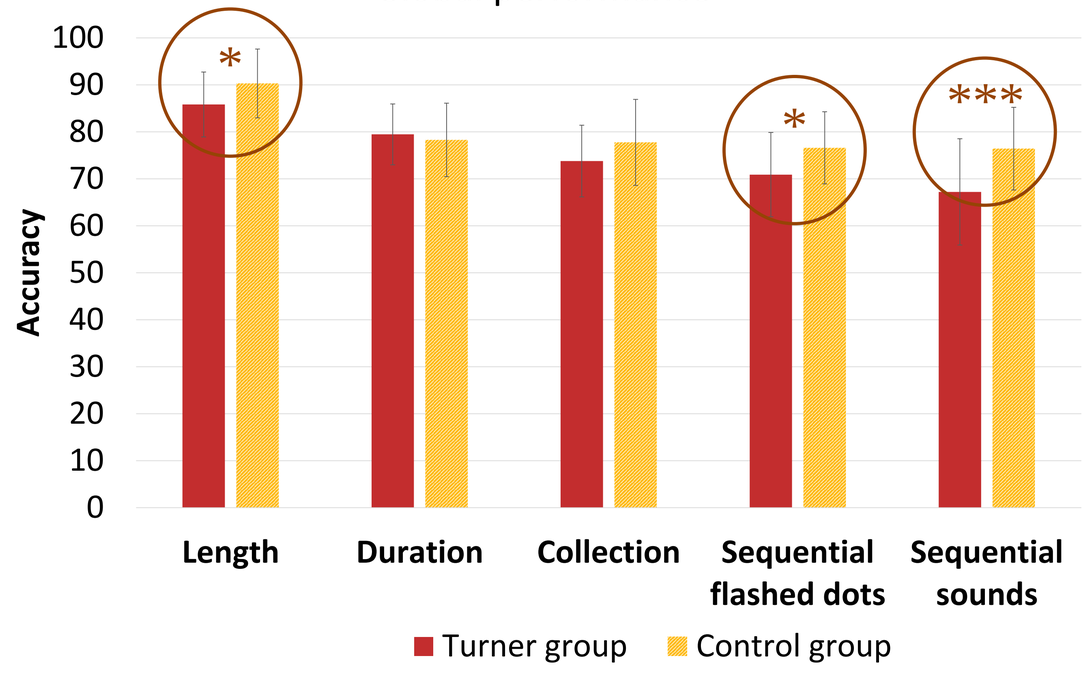
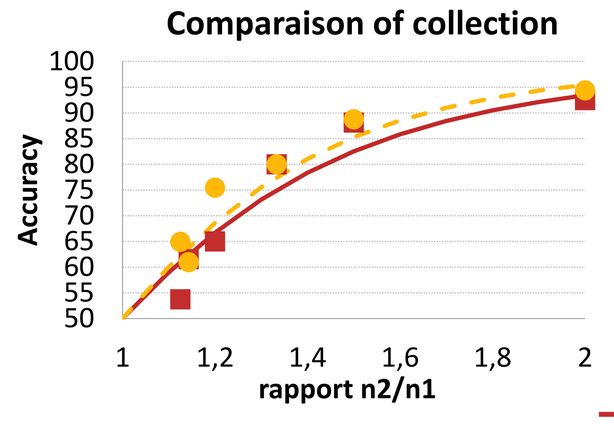
Results

Global performance

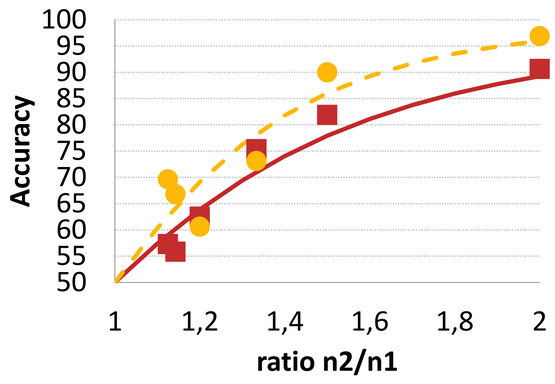


Paired T-tests on Weber fraction :
Significant group differences in **Sequential flashed dots and sounds** only

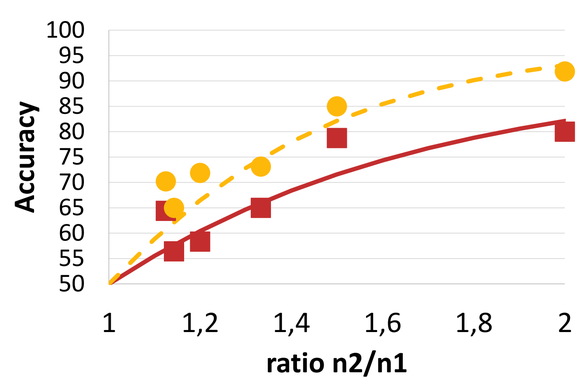
Comparaison of collection



Sequential flashed dots comparison



Sequential sounds comparison



Discussion

TS participants showed an impairment in the processing of :

- Continuous quantities requiring low visuo-spatial processing
- Discrete quantities when stimuli are presented sequentially

→ Possible influence of visuo-spatial abilities on the processing of continuous quantities (since duration judgment is preserved) but no influence on discrete quantitative representation (comparison of collection)

→ Specific deficit in the processing of numerical information presented in sequence for both auditory and visual stimuli

On one hand, this study highlights that numerical magnitude comparison of discrete non-symbolic quantities is not influenced by the visual cognitive load in TS participants and on the other hand it stress the importance to take into account the presentation format of stimuli, the sequential presentation being rarely investigated in numerical cognition research.

References

Simon, T., Takarae, Y., DeBoer, T., McDonald-McGinn, D., Zackai, E., & Ross, J. (2008). Overlapping numerical cognition impairments in children with chromosome 22q11. 2 deletion or Turner syndromes. *Neuropsychologia, 46*(1), 82-94.