CONTINUOUS REPRSENTATIONAL TRANSFORMATIONS:

Evidence that the Cerebellum Coordinates Movement on the Mental Number-line

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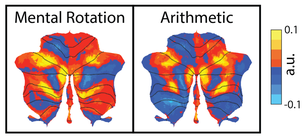
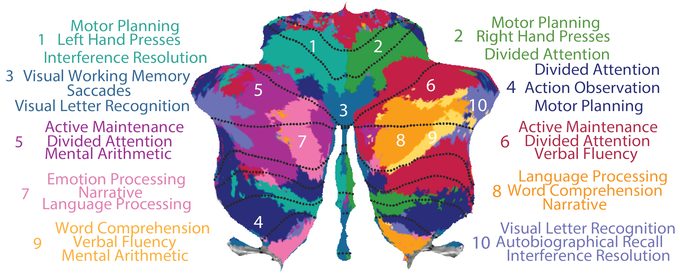
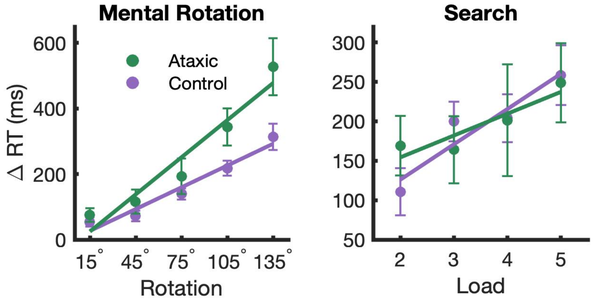
Background

- Neuropsychological and neuroimaging studies point to the involvement of the cerebellum in working memory [1]
- Individuals with spinocerebellar atrophy (SCA) were impaired only in mental rotation but not memory search [2]
- Could the Cerebellum be selectively involved when internal representations are continuously transformed?
- We tested this hypothesis in the numerical cognition domain
- Simple-digit addition RT becomes longer as the sum increases, attributed to the time required to traverse a continuous mental number-line [3, 4]



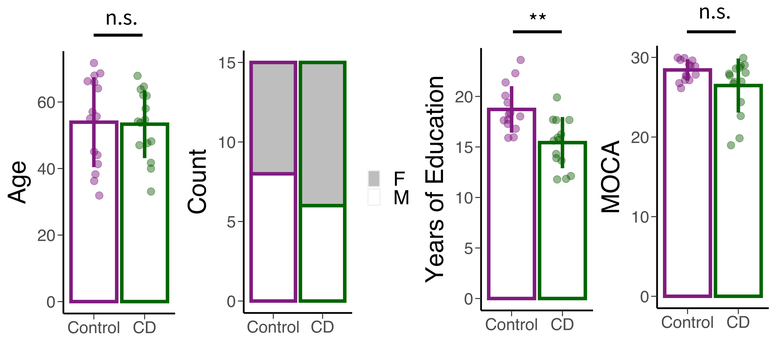




Method

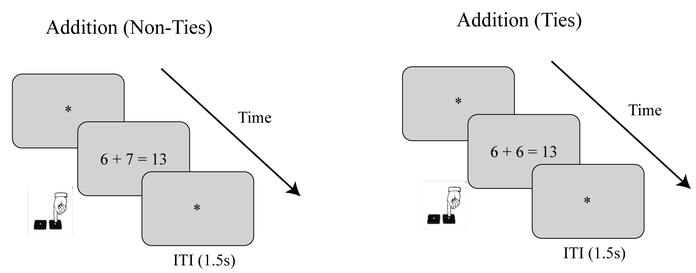
Participants (15 patients & 15 controls)

- Differing Pathologies: SCA1 (1), SCA2 (2), SCA3 (3), SCA8 (1), AOA2 (2), Unknown (6)

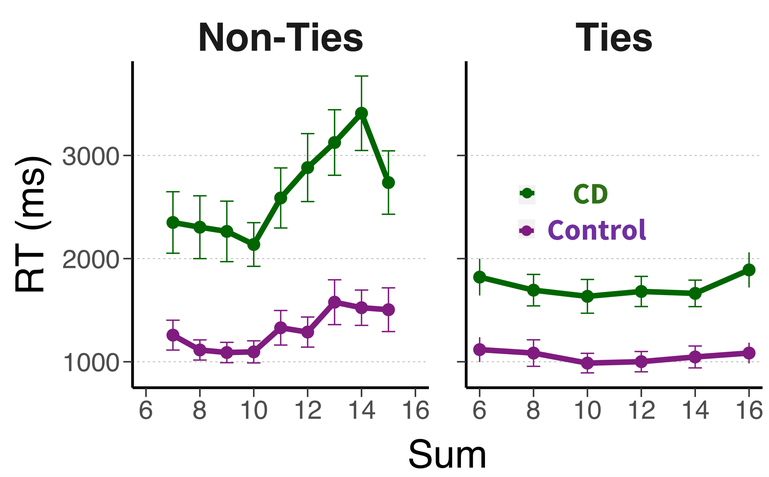


Sum Verification Task

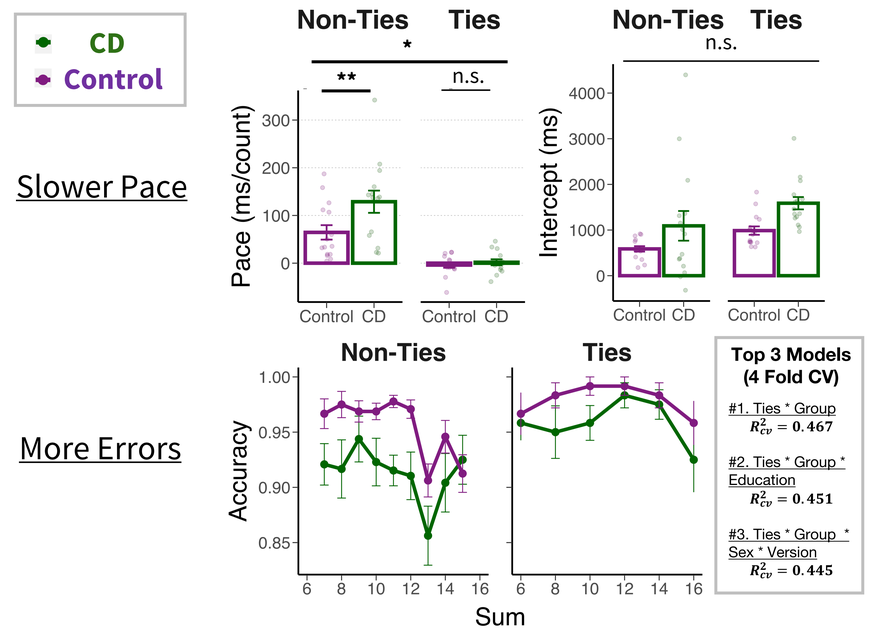
Cerebellar-Dependent (CoRT) | Non-Cerebellar-Dependent (non-CoRT)



Steeper Slope in Non-Ties RT

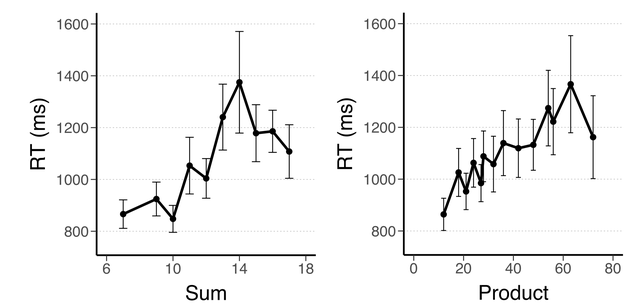


Reliable Ties x Group Interaction



Other Continuous vs Discrete Tasks?

Add vs Mult



Endo vs Exo Attention

Language

Predictability	CoRT	Non-CoRT
High	He loosened the tie around his ____.	Her job was easy most of the ____.
Moderate	She reached her hand into the fruit bowl and took out a ____.	He wondered whether it was coincidence or ____.
Low	A large stone blocked the entrance of the ____.	The state park was popular for its large ____.

Acknowledgments and References

[1] King, 2019 [2] McDougle, in prep. [3] Dehaene, 1993 [4] Hubbard, 2005. We thank Guy Avraham for assistance in data collection.

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Evidence that the cerebellum coordinates movement on the mental number line

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Abstract:
Neuropsychological and neuroimaging studies point to the involvement of the cerebellum in working memory tasks, although the nature of this contribution is poorly understood. McDougle et al., (in preparation) recently tested individuals with spinocerebellar atrophy (SCA) on two tasks that tap into working memory, mental rotation and memory search, with the SCA group only impaired on the former. They hypothesized that mental rotation involves the manipulation of a mental representation in a continuous manner, whereas memory search requires a sequential operation applied to distinct representations. To test this hypothesis in a new context, we compared SCA (n = 15) and control (n= 13) participants on an arithmetic task requiring the verification (true or false) of single-digit addition problems (e.g., 7 + 5 = 13). For problems such as these, RT becomes longer as the magnitude of the sum increases. This has been attributed to the time required to traverse a mental number-line. In contrast, the RT function is relatively flat for addition problems involving the same number, or what are called “ties” (e.g., 4 + 4 = 9), presumably because the answer to these problems can be retrieved from an over-learned look-up table. The RT data for the SCA group showed a larger slope on the non-ties compared to the control group, but no slope difference was observed between the groups on the ties. These results provide further evidence that the cerebellum is recruited for “cognitive” tasks that required the continuous manipulation of a representation, perhaps reflecting an embodied form of internal simulation and a generalization of a functional role for this structure in coordinating movements.