THE REPRESENTATION OF ORDINAL INFORMATION: DOMAIN SPECIFIC OR DOMAIN GENERAL ?

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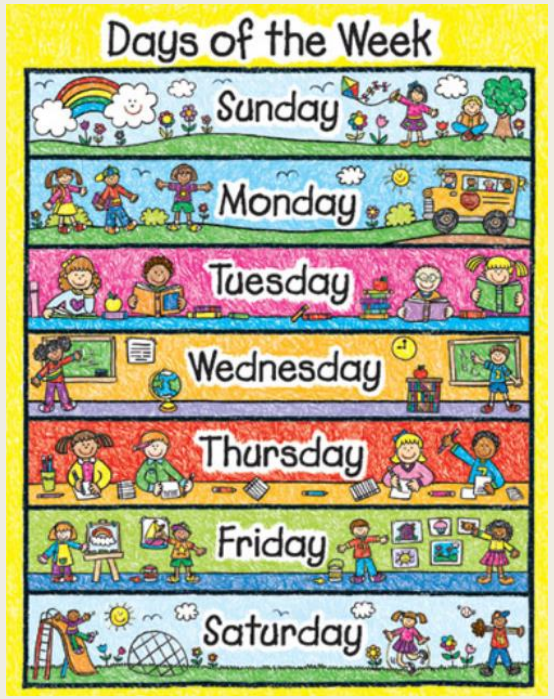
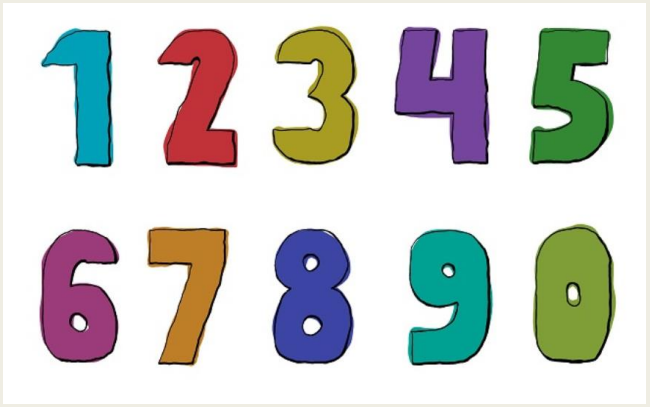
Ordinal processes

To process the sequential relations between stimuli of a stimulus set





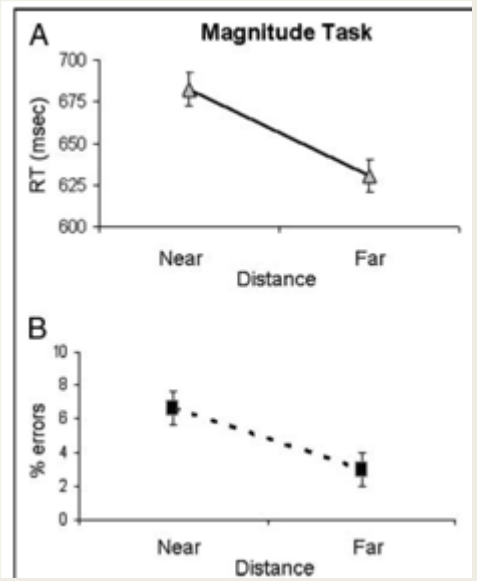
Distance effect

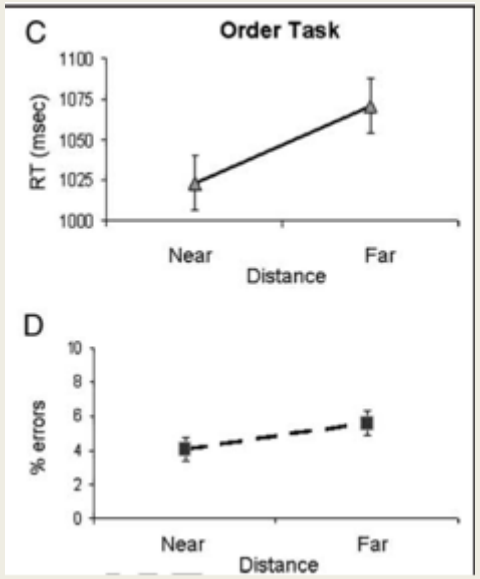
Which is the largest ?
→ Standard distance effect

Are they in order ?
→ Reverse/ordinal distance effect

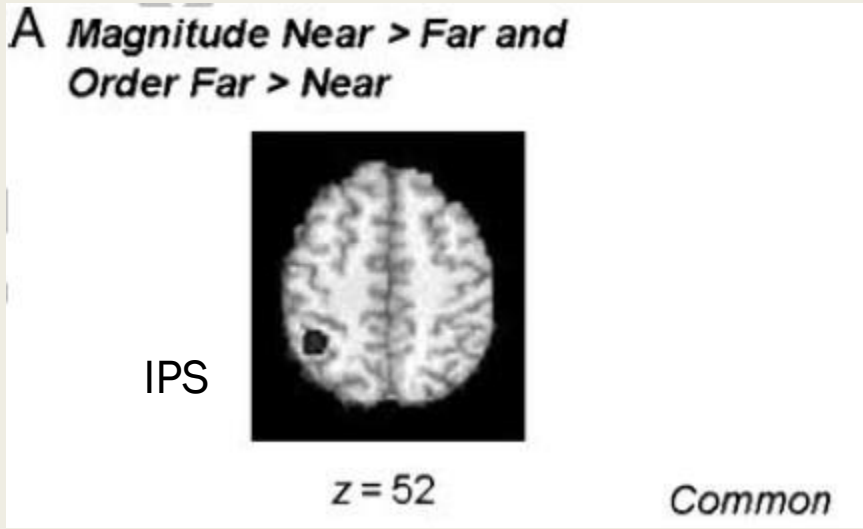
2	3	<	2	8

2	3	>	2	8



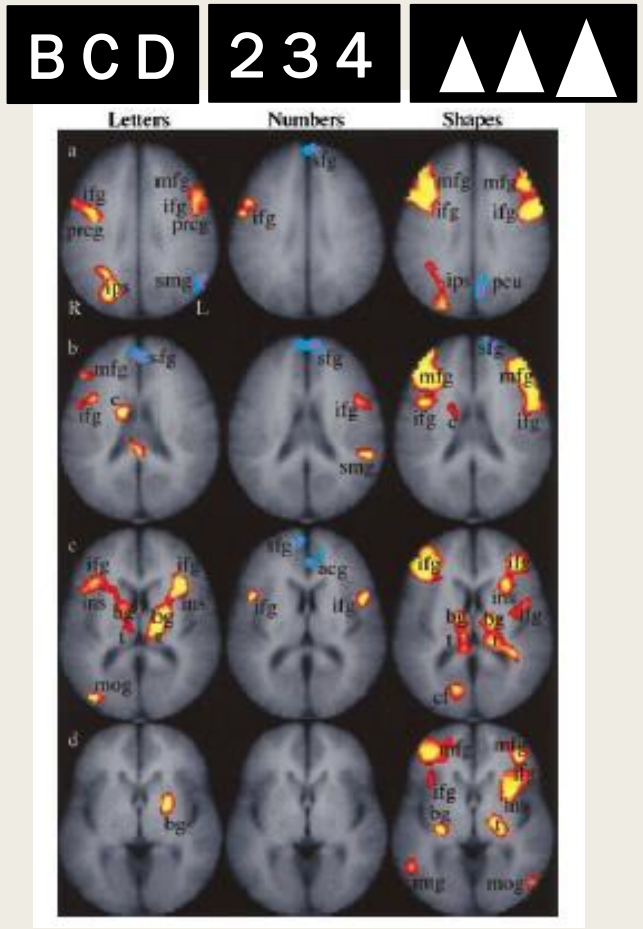


						Activity (Peak t Score)	
Regions	*BA*	*x*	*y*	*z*	*No. of Voxels*	*Mag Near > Far*	*Order Far > Near*
Common Regions							
Mag Near > Far and Order Far > Near							
Left IPS	40	−40	−52	52	27	3.45	3.11

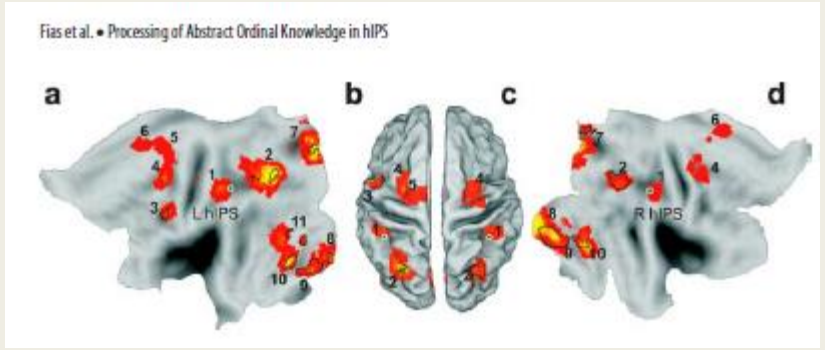


Franklin & Jonides (2009) JoCN

Common distance effect

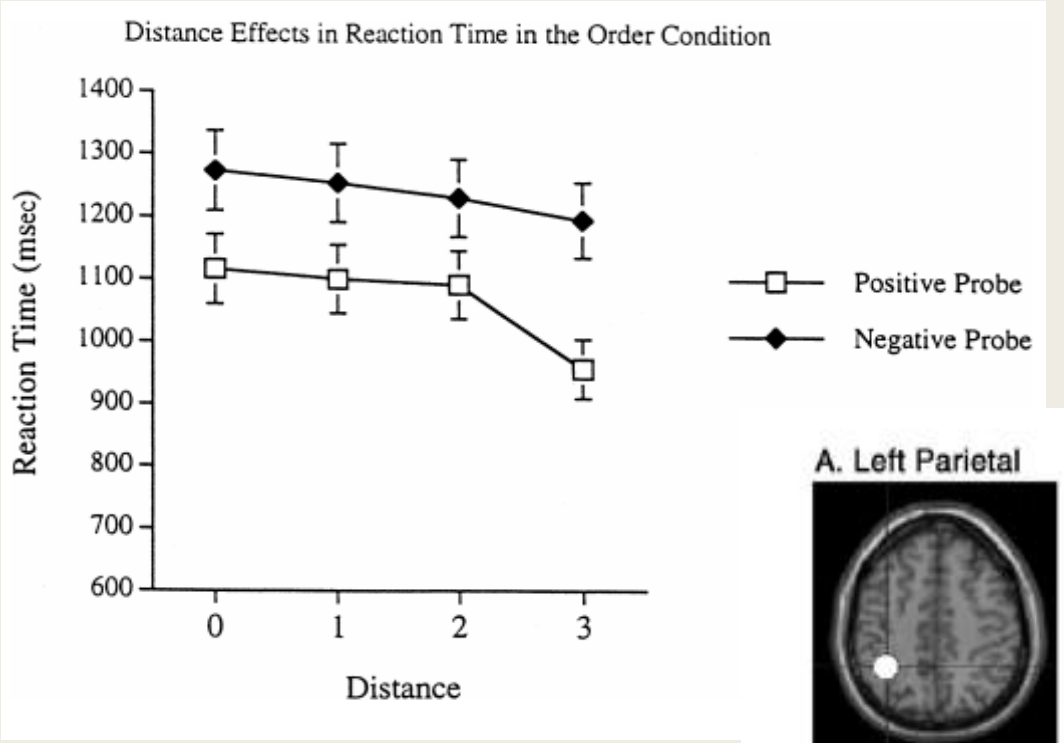


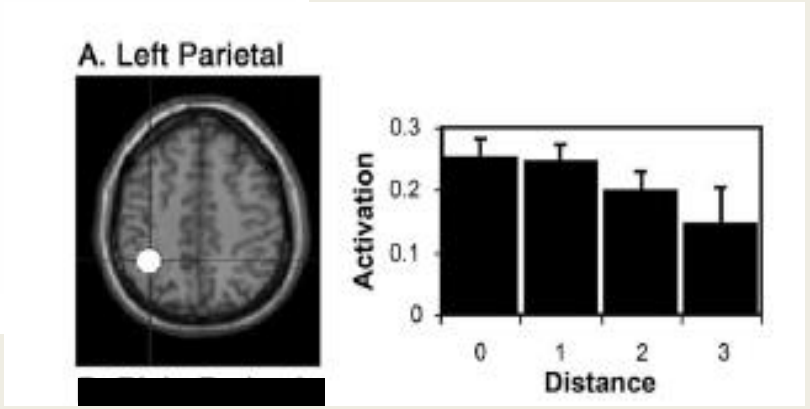
Fullbright et al. 2003, JoNS



Fias et al. 2007, JoNS

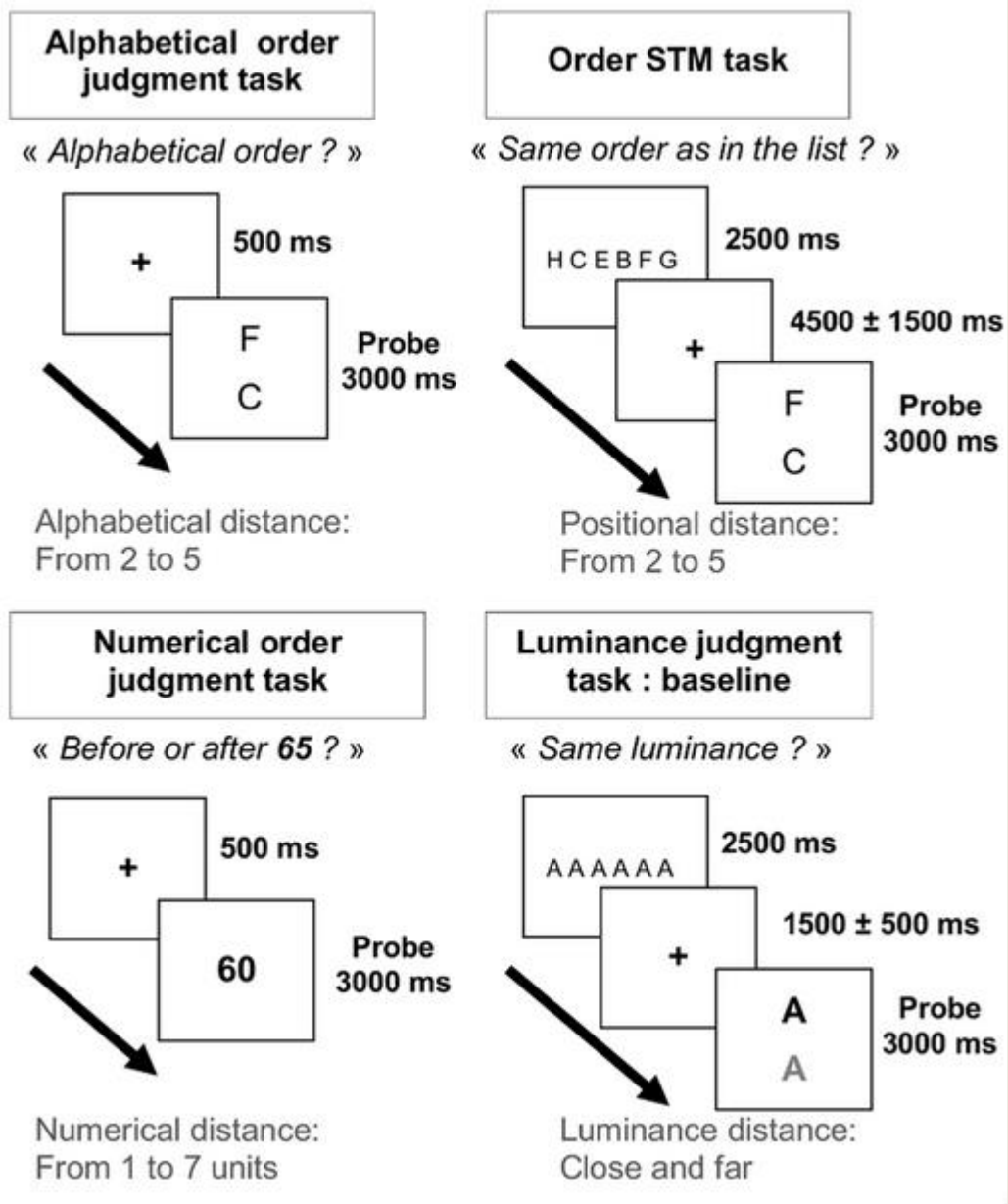
Distance effect in WM

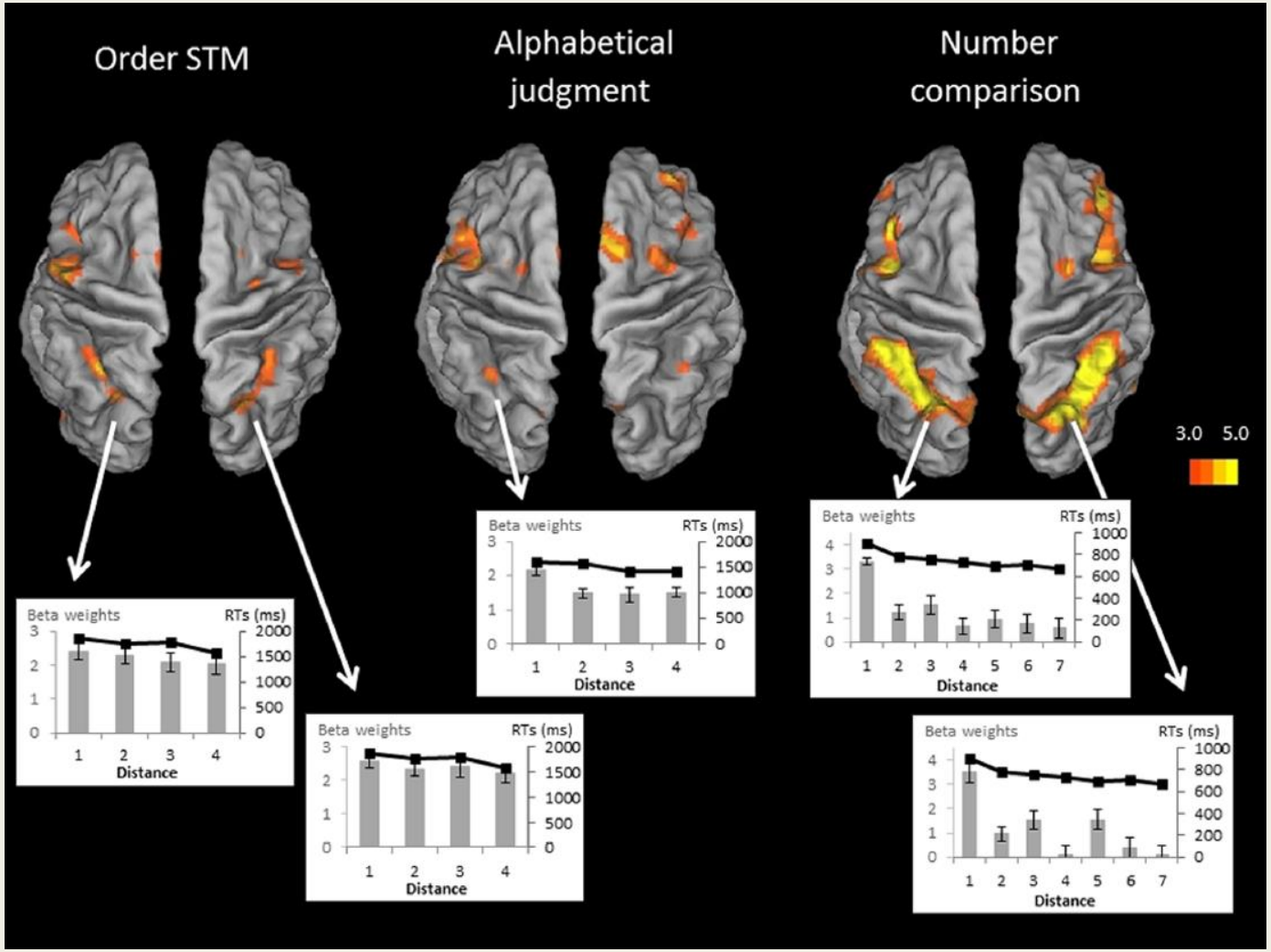




Marshuetz et al., 2000; Attout et al. 2104

A B C D E → *A B C D E* > *A B C D E*





Attout, Fias, Salmon, Majerus (2014). Plos One

- Previous studies support the existence of common neural mechanisms to process ordinal information
- BUT no direct evidence
- Similar brain networks ≠ same information is processed
- Other paradigm → different brain network

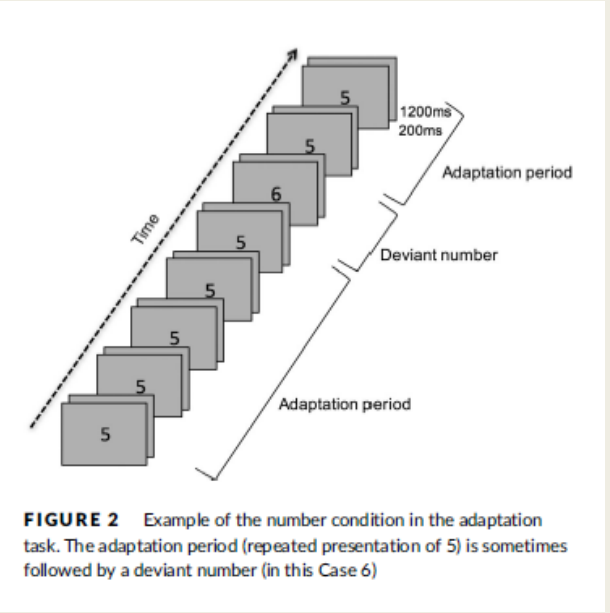


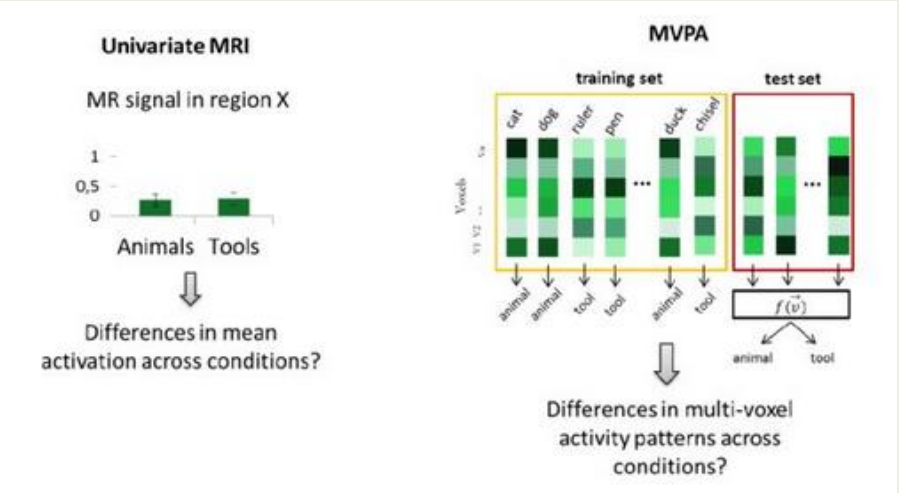
FIGURE 2 Example of the number condition in the adaptation task. The adaptation period (repeated presentation of 5) is sometimes followed by a deviant number (in this Case 6)

Goffin & Ansari (2019)

Aim

- We assessed the hypothesis of domain-general codes for the representation of ordinal information across WM, numerical and alphabetical domains by assessing the neural similarity of **voxel activity patterns** associated with **the ordinal distance effect**.

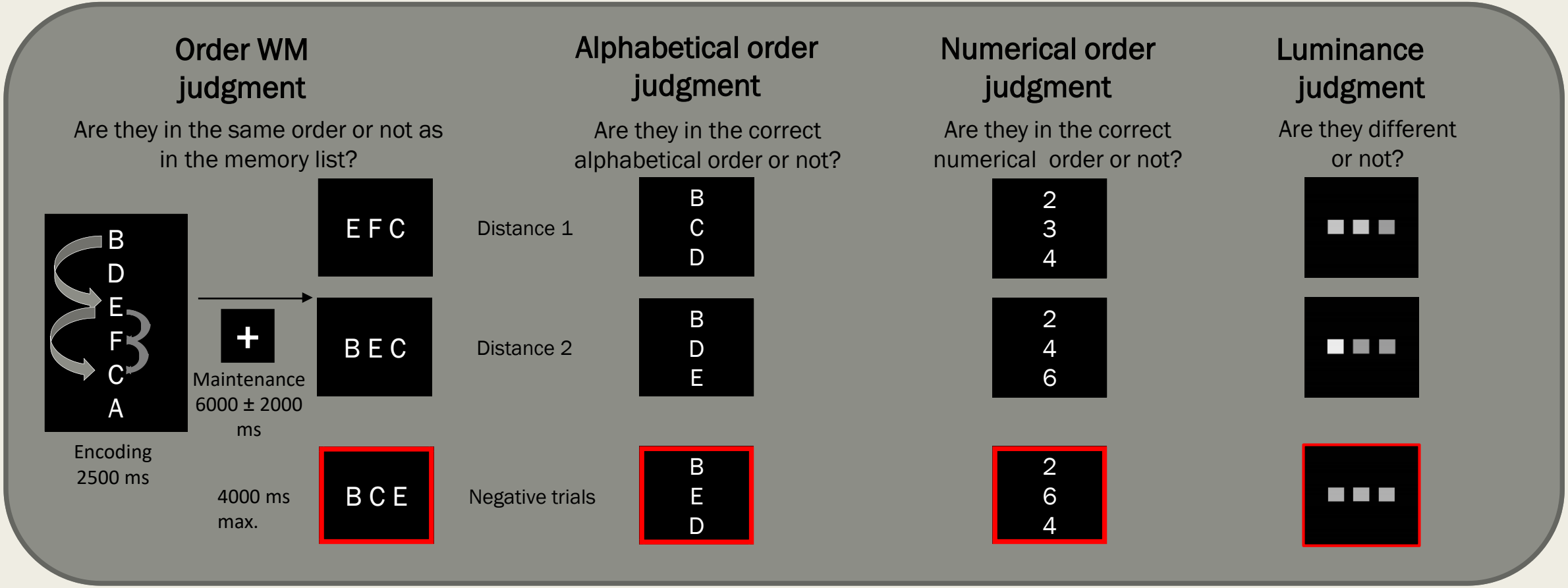
→ MVPA analyses



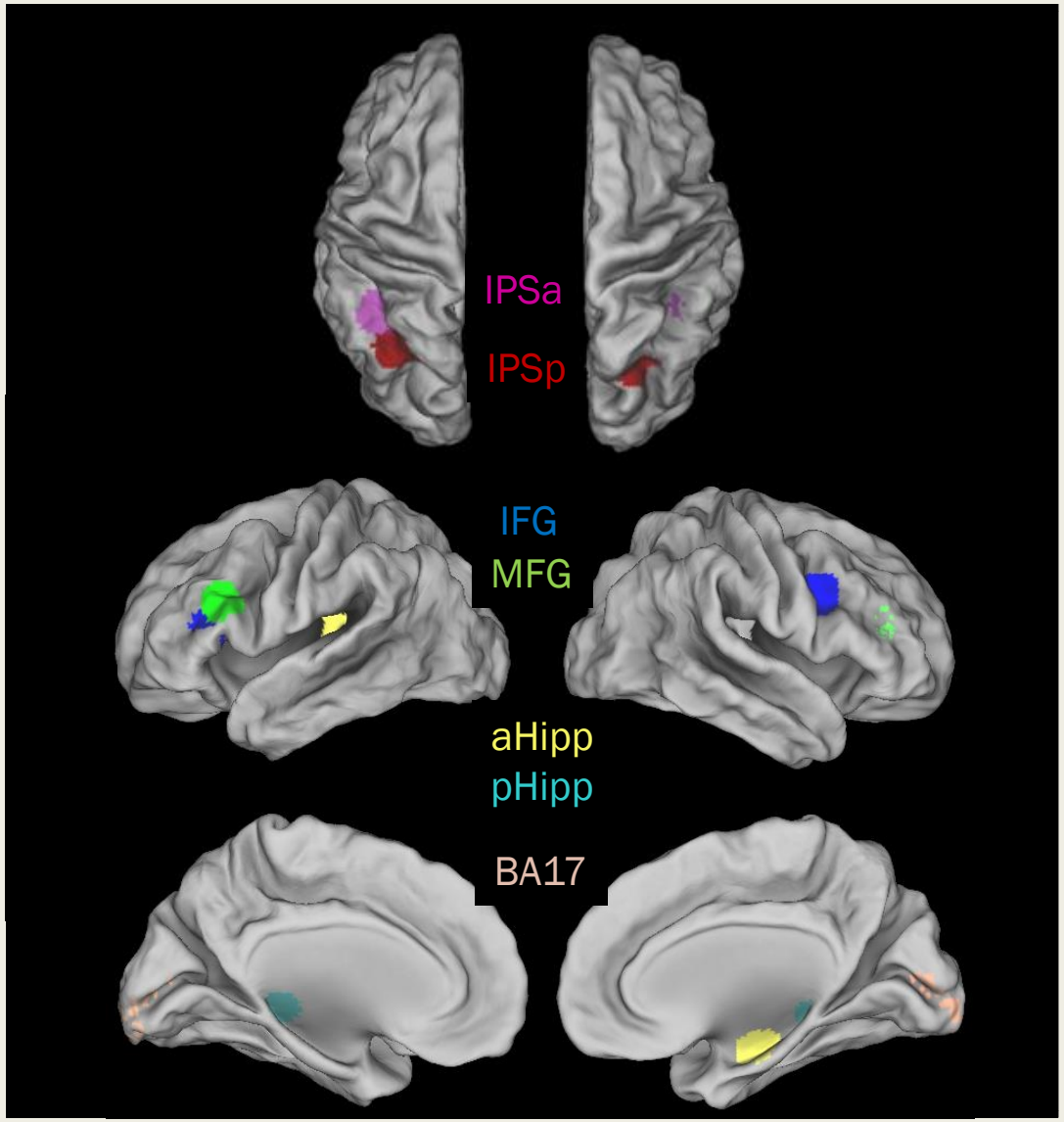
→ judgment of triplets

Method

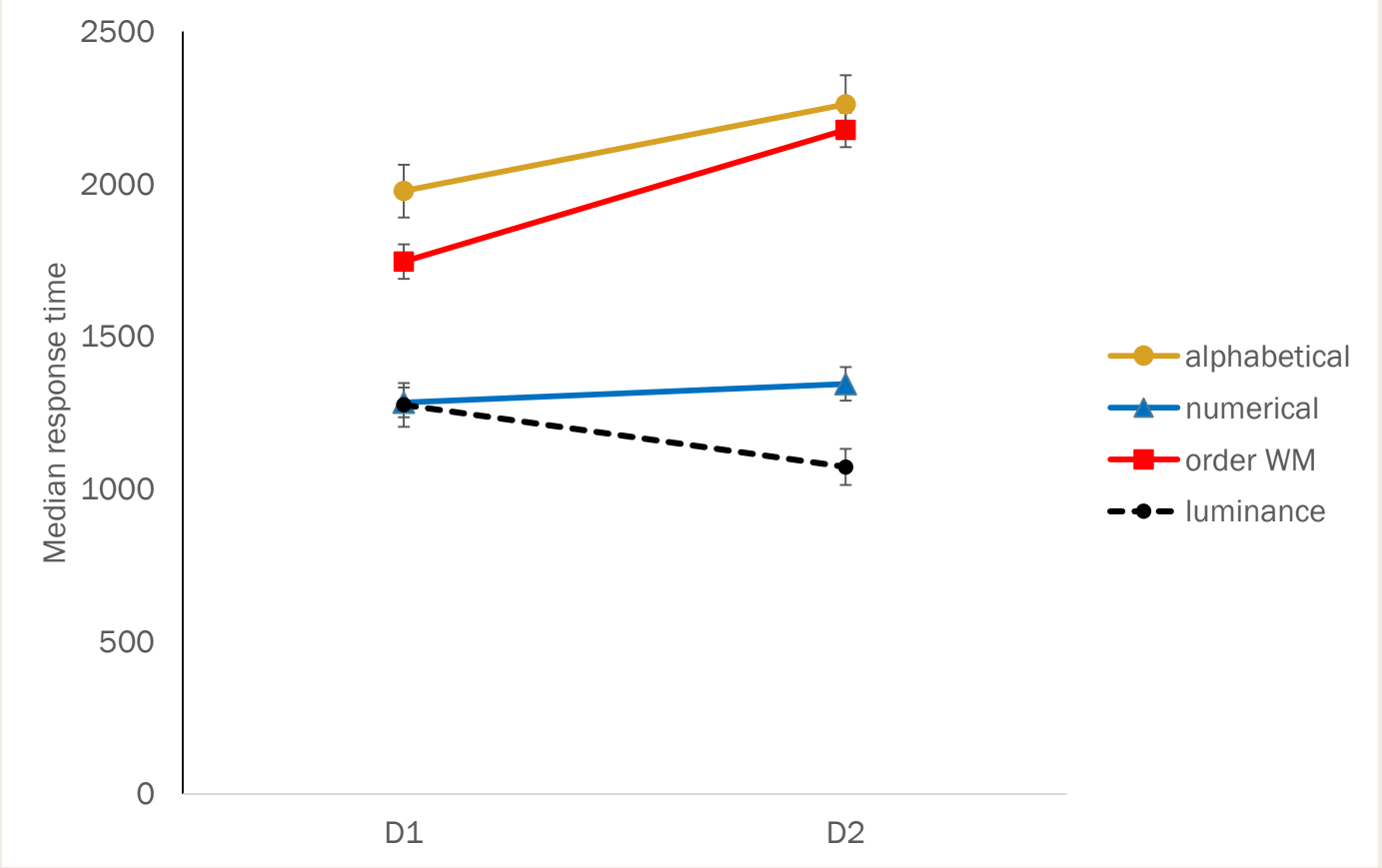
Participants: 34 young adults (22 women) aged from 19 – 33 (23.30 ± 2.80 years old)



ROIs



Results: Behavioral



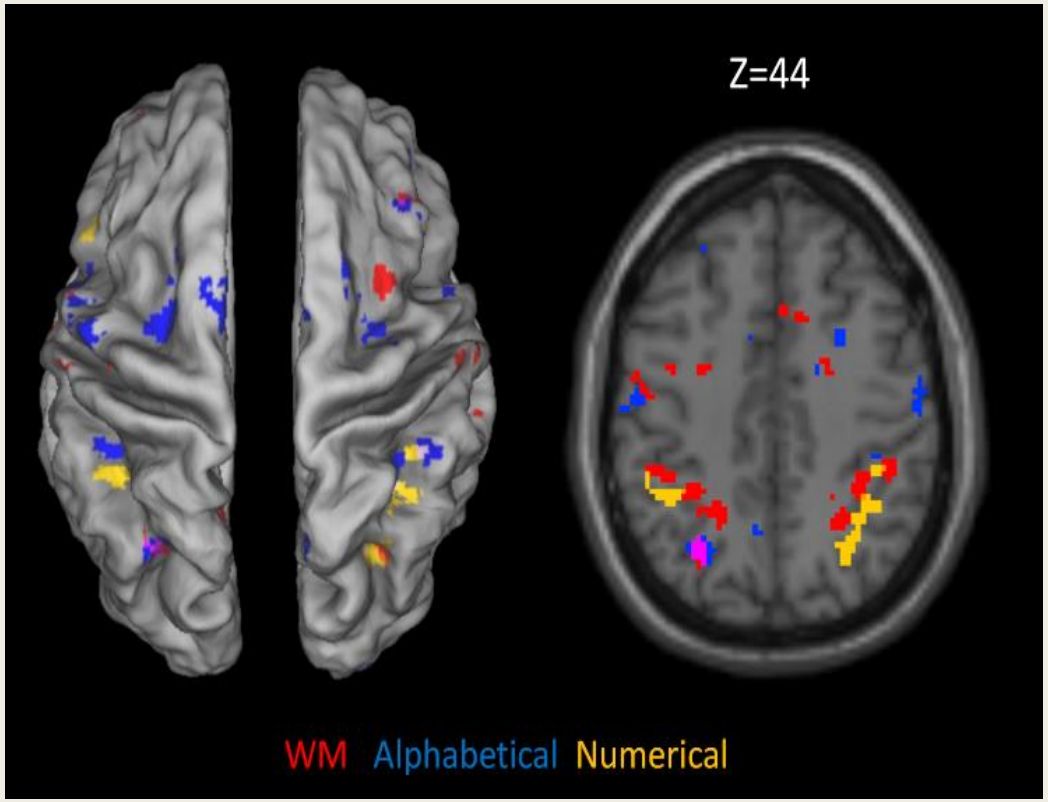
Main effect of Task : BF_{10}=1.15E+51

Interaction effect: BF_{10}=1.89E+60

→ Ordinal DE for all ordinal judgment tasks
→ Standard DE for the luminance judgment task

Results: fMRI

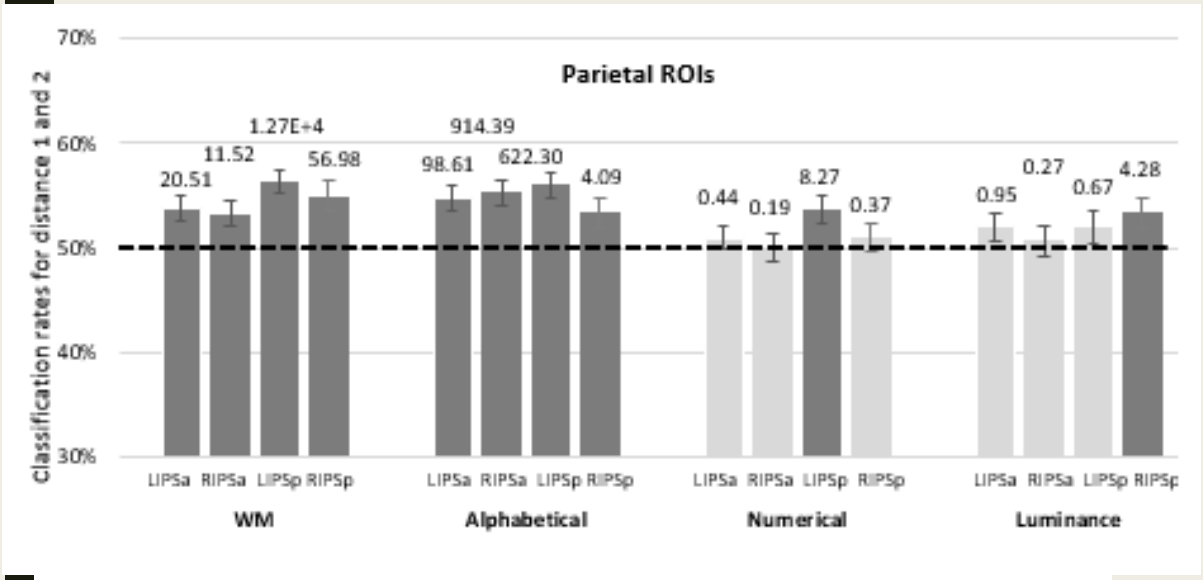
- Univariate

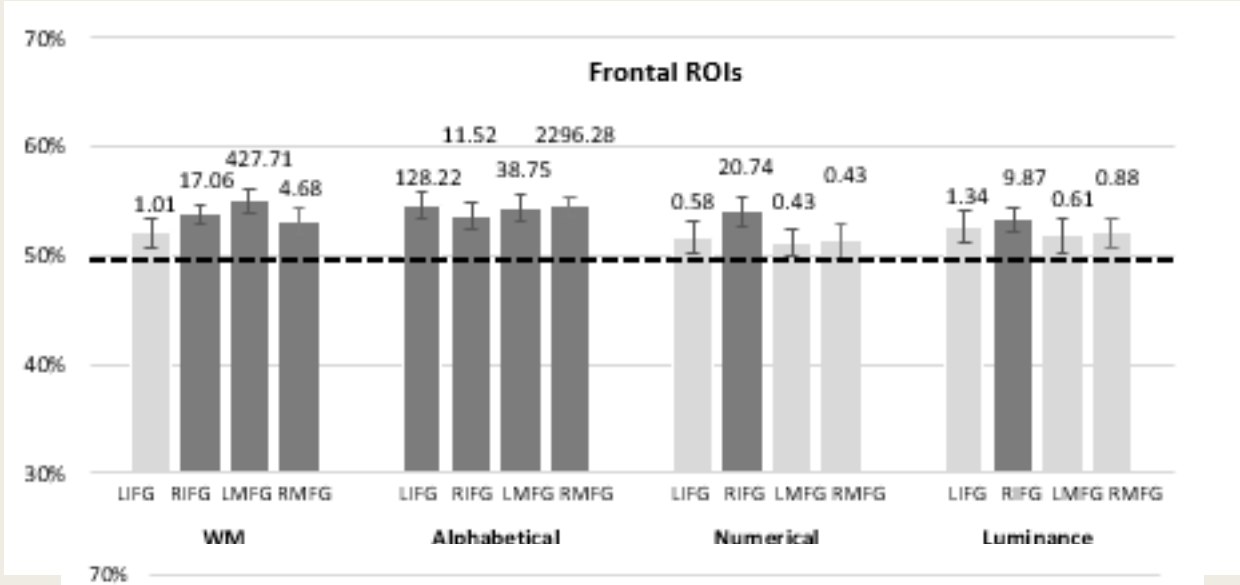


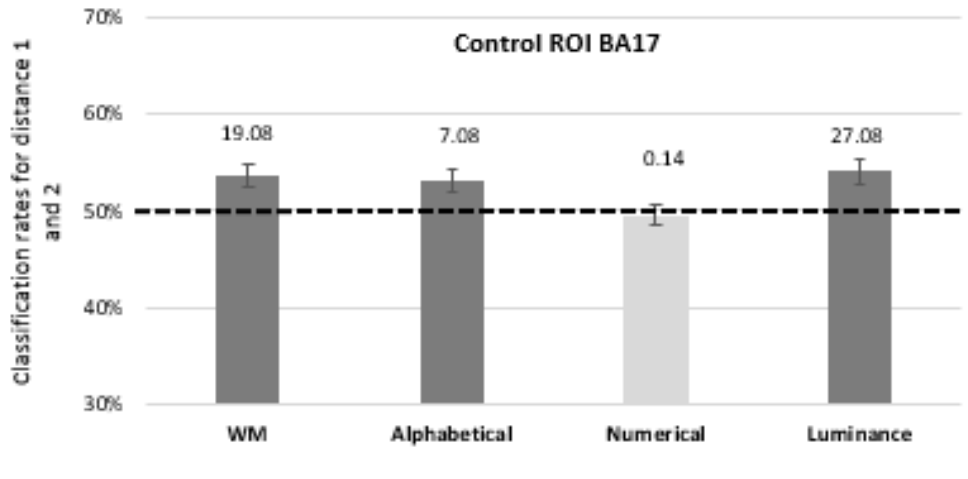
	No. voxels	Left/ right	x	y	z	SPM Z - value
Ordinal distance effect for order WM (D2<D1)						
IPSa	26	L	-30	-44	44	**3.79***
	50	R	46	-36	40	**4.25***
IPSp	96	L	-28	-64	44	**4.26***
Ordinal distance effect for ordinal alphabetical judgment (D2<D1)						
IPSp	43	L	-28	-64	44	**4.24***
	11	R	30	-62	38	**3.50***
Ordinal distance effect for ordinal numerical judgment (D2<D1)						
IPSa	69	L	-38	-44	40	**3.81***
	28	R	38	-38	40	**3.73***
IPSp	71	R	32	-60	46	**4.00***
MFG	57	L	-48	22	22	**3.98***
	18	R	46	40	22	**3.89***
IFG	34	L	-36	28	20	**4.06***
Standard distance effect for luminance judgment (D1<D2)						
BA17	6	R	16	-94	-4	3.57[a]

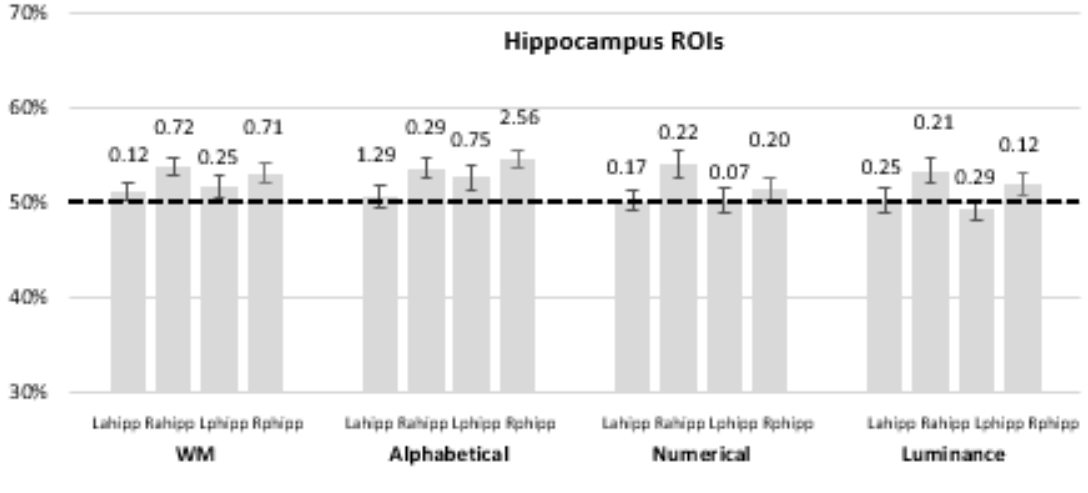
Results: fMRI

- MVPA Classifications D1 – D2 : **within task**



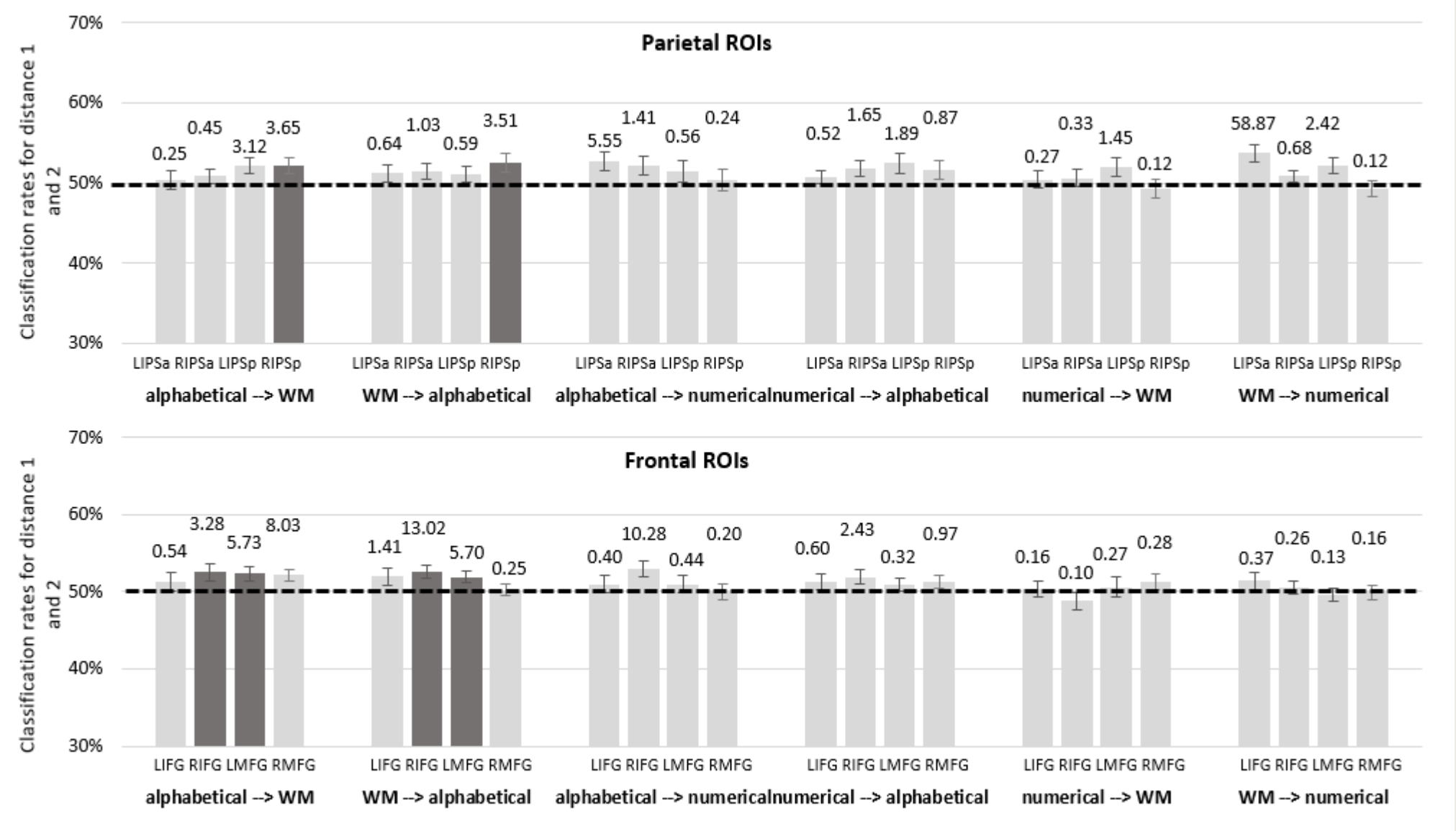






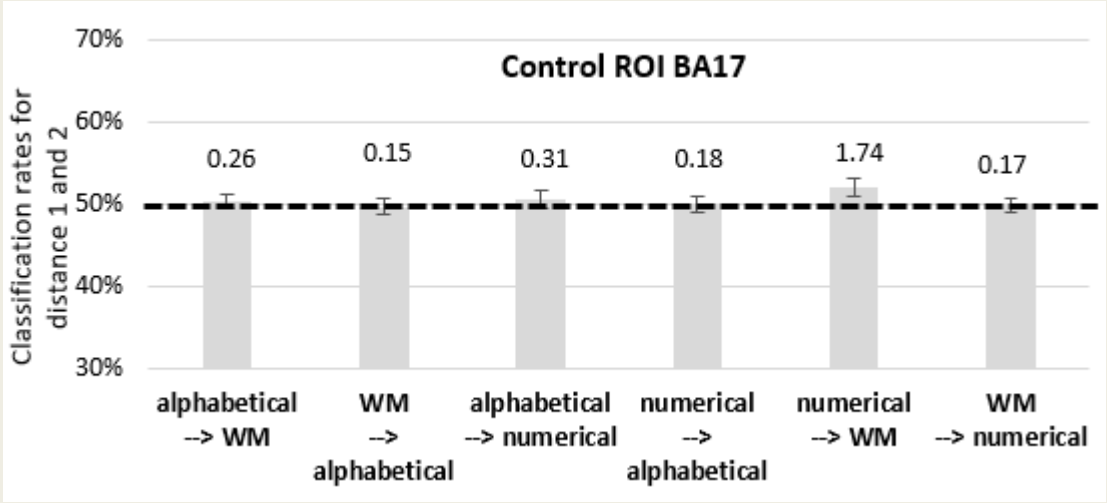
Results: fMRI

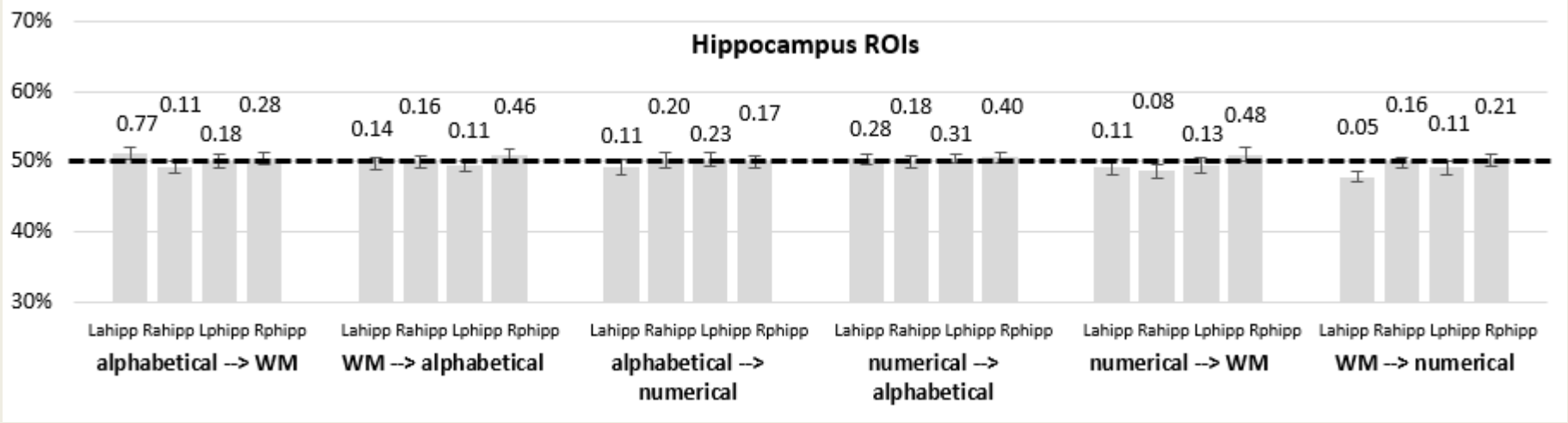
MVPA Prediction between tasks



Results: fMRI

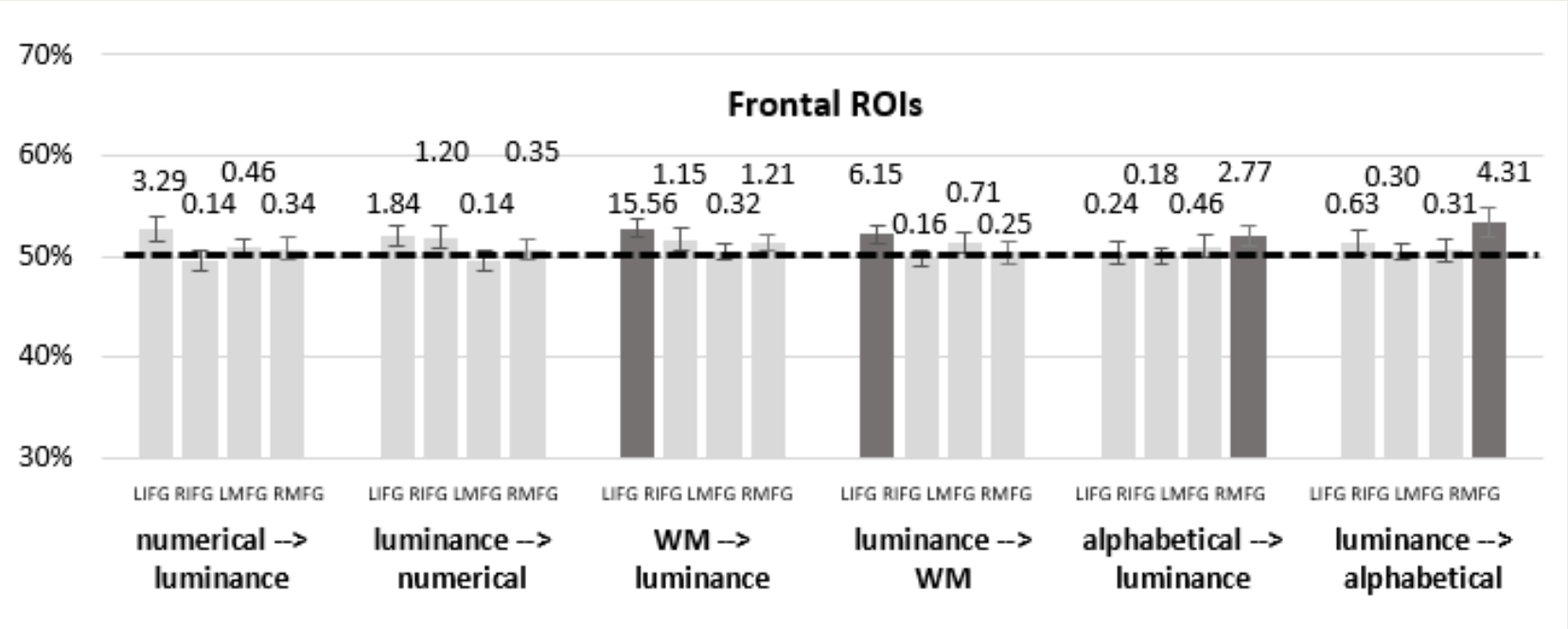
MVPA Prediction between tasks





Results: fMRI

Between task prediction with **luminance judgment**



Discussion

- Sensitivity to ordinal distance in fronto-parietal cortices (not at hippocampal level)
- Between domain prediction of ordinal distance was only reliable between the serial order WM and the alphabetical tasks in the **right posterior IPS**, the **right inferior frontal** and the **left middle frontal** ROIs
- Between-task prediction of distance between the luminance judgment and both, the WM and alphabetical judgment tasks, in the two frontal ROIs

Discussion

- Domain-general implication of fronto-parietal cortices BUT not support the hypothesis of domain-general ordinal codes per se
  - *prediction of ordinal distance only for the order WM and alphabetical tasks, but not for the numerical domain*
  - *prediction not specific to ordinal distance → luminance distance*

‘hard-vs-easy’ dimension → different levels of attentional control

Discussion

- posterior IPS ROI → did not allow for prediction between luminance and ordinal distances
- more specific role for ordinal processing ?
- A spatial-attentional role of the posterior IPS
  - *Differentiated neural signals for leftward versus rightward orientation of attention (Yantis et al. 2002; Silver and Kastner 2009; Vandenberghe and Gillebert 2009; Bressler and Silver 2010; Gillebert et al. 2011).*
  - *Mental whiteboard hypothesis : attentional spatial frame could allow to temporarily organize memoranda and letters on a horizontal line, ordered from left to right (Abrahamse et al. 2014, 2017)*

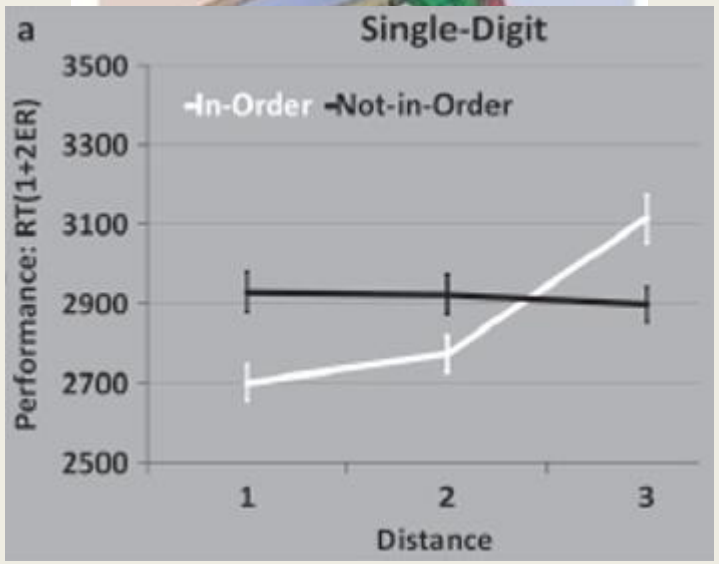
Conclusion

- Domain-general involvement of a fronto-parietal network in the processing of ordinal distance.
- BUT this fronto-parietal network appears to reflect the differential involvement of top-down and spatial attentional resources rather than domain-general coding of ordinal representations.

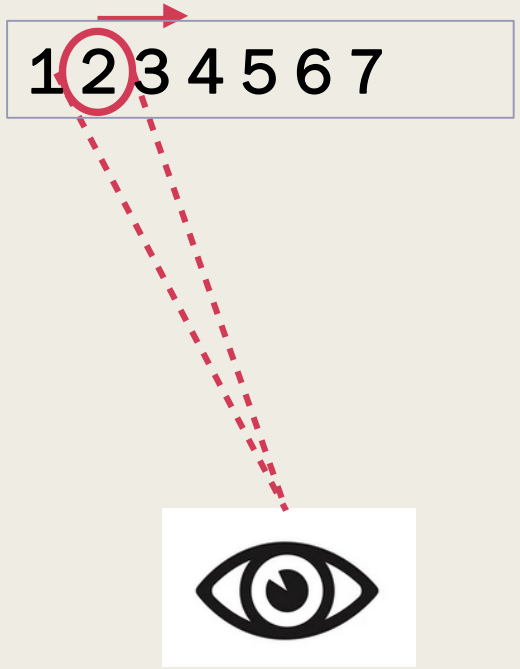
THANK YOU FOR YOUR ATTENTION

Distance effect

- Triplets → reverse distance effect

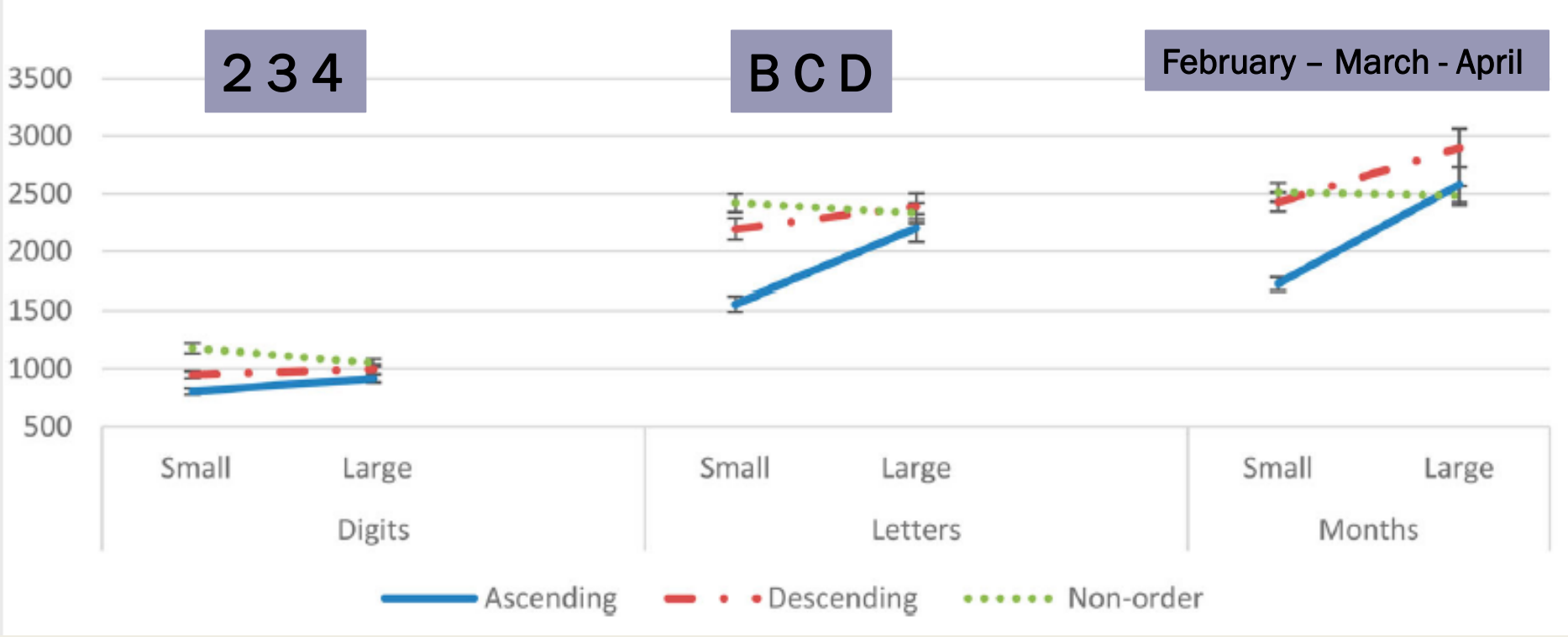


Lyons & Ansari, 2015



Distance effect

- Ordinal distance effect in other domains

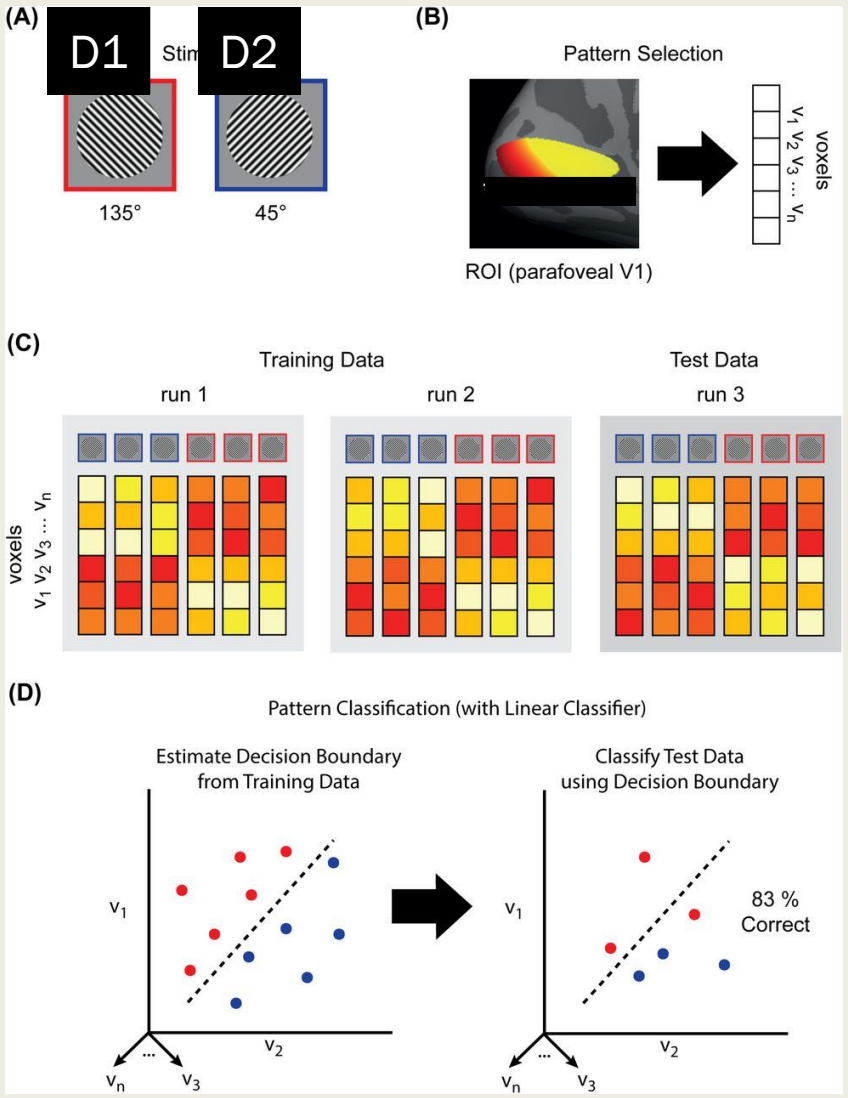


Vos et al., 2017

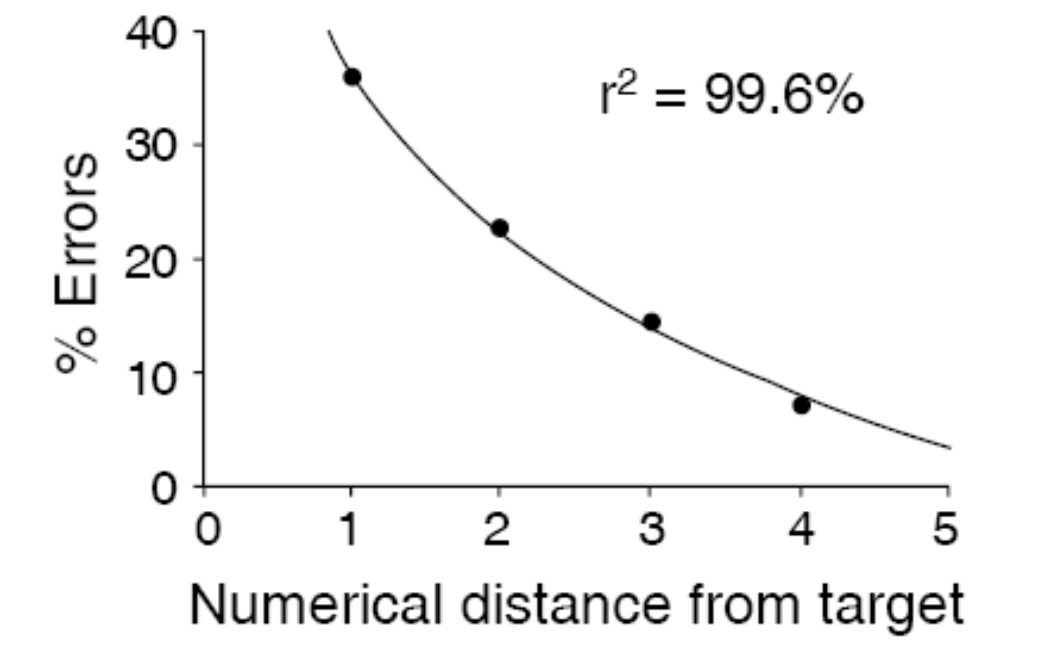
MVPA analyses

Within : Leave-one-block-out (LOBO) cross-validation procedure

Between : Leave-one-run-out (LORO) cross-validation procedure



- Distance effect (Moyer & Landauer, 1967)



6 < 1

2 8 < 2 3 ⟹ Distance effect

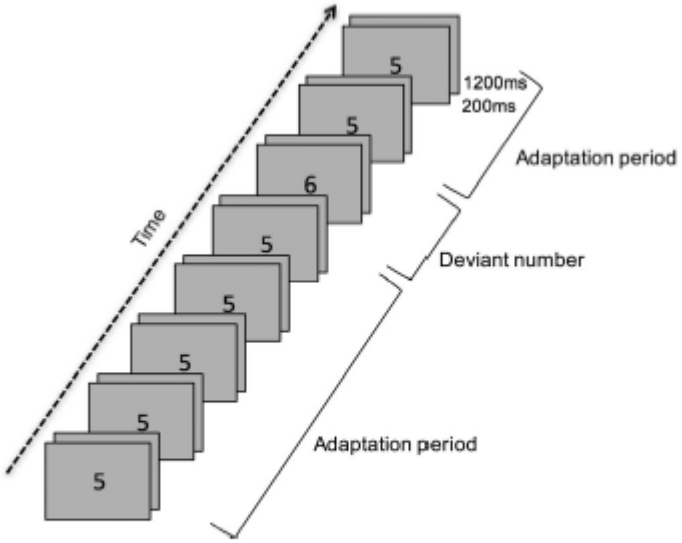
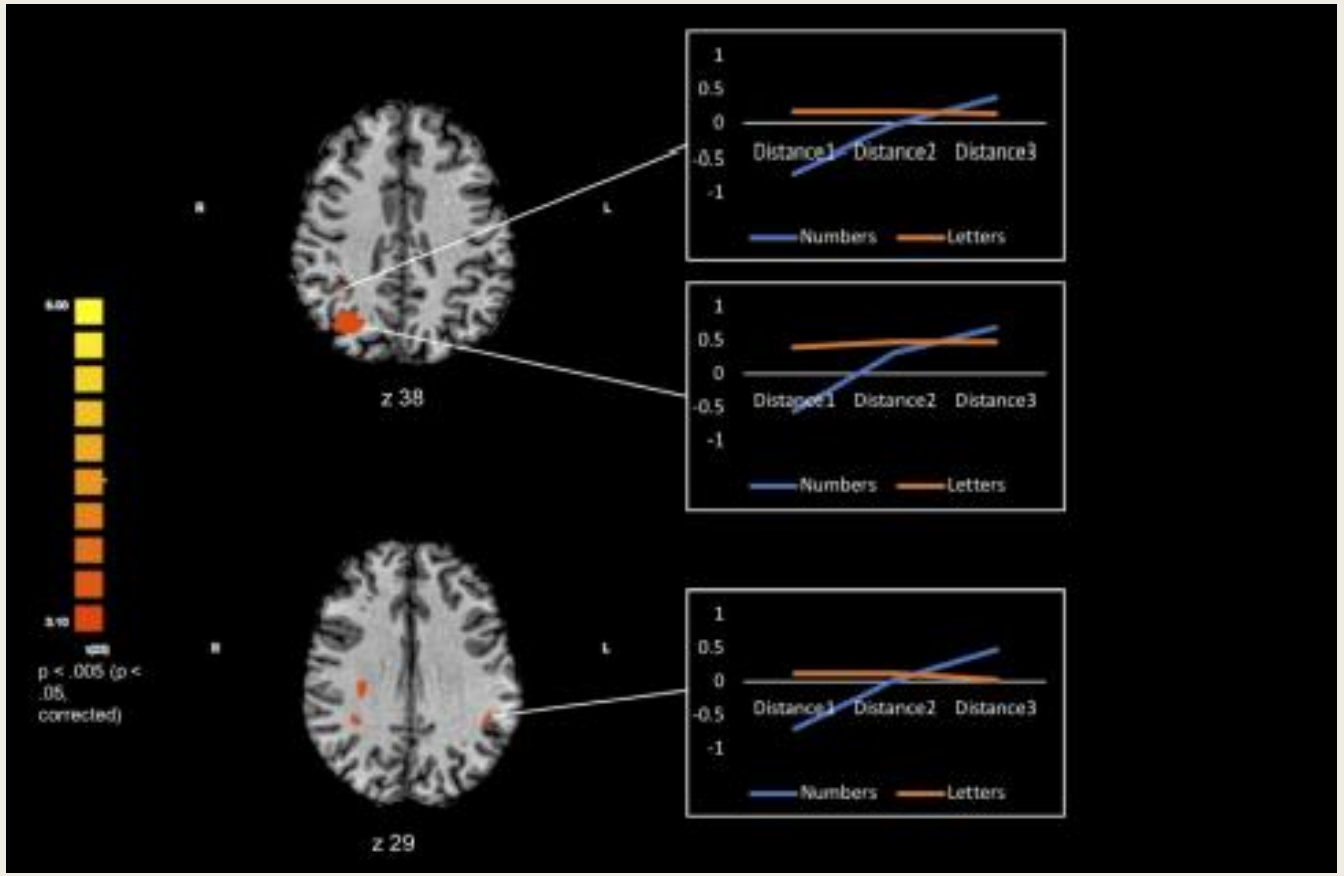


FIGURE 2 Example of the number condition in the adaptation task. The adaptation period (repeated presentation of 5) is sometimes followed by a deviant number (in this Case 6)



Goffin & Ansari, 2019

Order WM

- A main function of the working memory (WM) is to code and maintain the serial order of the item positions in memory

0 4 9 4 / 4 9 6 8 2 4

Item : /O/ /foR/ …

Order : 0=1st, 4=2nd , 9=3rd , 4=4th

→ Crucial for many activities that are defined by sequential processing such as oral language processing, written language, mental calculation or problem solving.