

'What' and 'Where' we remember

- an anatomo-functional dissociation within Verbal Short-Term Memory -

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Background

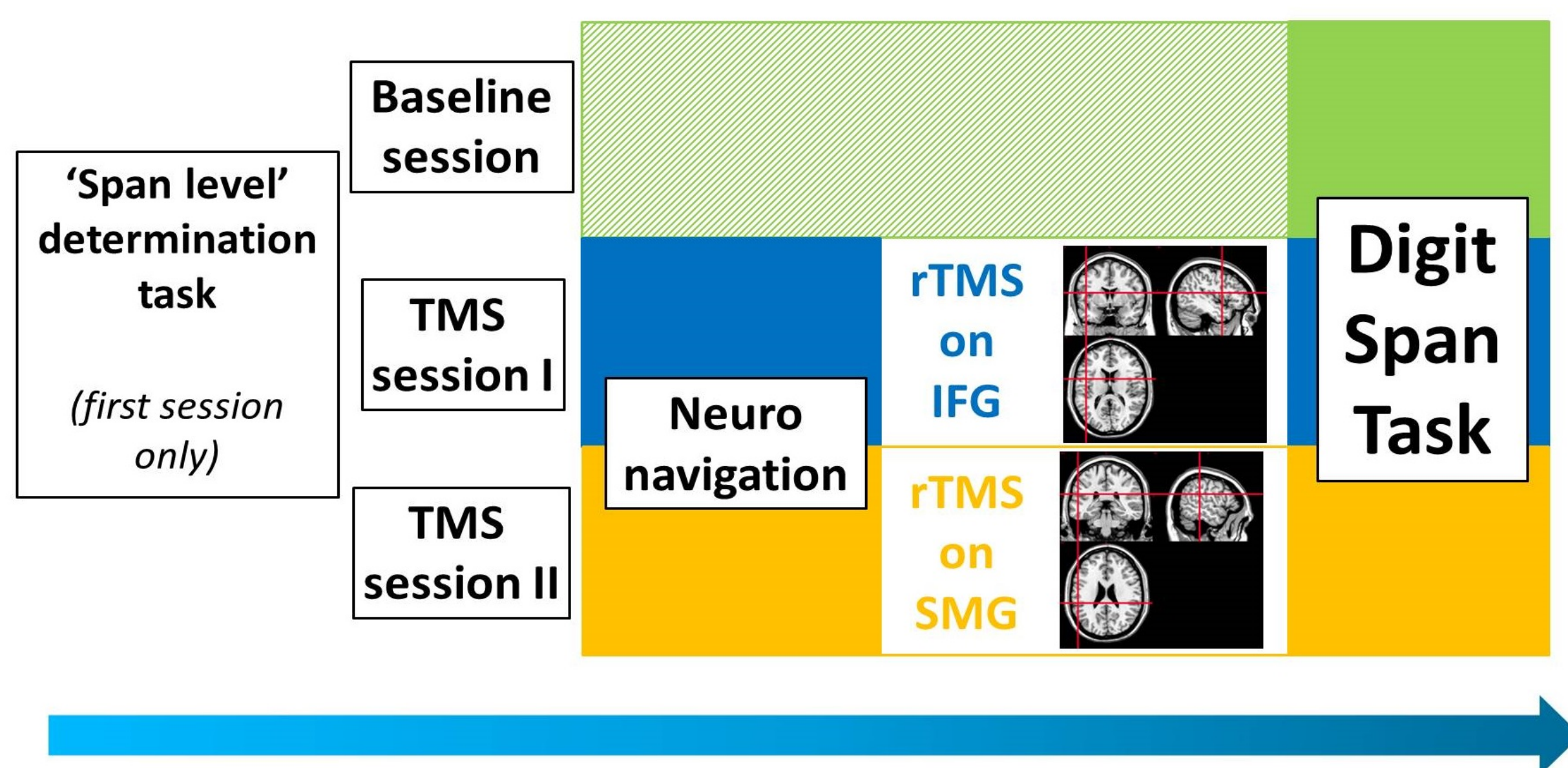
The anatomo-functional specialization of the cerebral areas involved in verbal *Short-Term Memory* (STM) network has been investigated on neurosurgical patients, highlighting how the two main areas of this network, the **left Inferior Frontal Gyrus (IFG, Brodmann Area 44)** and the **left Supra-Marginal Gyrus (SMG, Brodmann Area 40)**, are specialized in the storage of **content information** and of **order information**, respectively (Papagno et al., 2017).

Aims

We aim to provide **evidence in healthy subjects, by means of repetitive Transcranial Magnetic Stimulation (rTMS), of the causal role of IFG and SMG in the short-term storage of verbal content information and order information**. Furthermore, preliminary data suggests that SMG is also involved in storing visuo-spatial serial position information.

Methods

Procedure



- 3 randomized sessions (**Baseline**, **IFG stimulation**, **SMG stimulation**) separated at least by 24 hours.

Participants

- 20 healthy right-handed subjects (16 F, 4 M);
- Mean span: 6,5.

Auditory-verbal digit span task

- 45 randomized sequences based on the span level of the subject (determined preliminary during the first session) to immediately recall;
- Computerized presentation (1 digit/s);
- Responses registered by the experimenter via PC-keyboard.

rTMS

- 1 Hz, 10 minutes (600 pulses) at 100% resting Motor Threshold (rMT);
- Off-line, before the execution of the digit span task;
- Tailarach coordinates of **left IFG (x: -42, y: 2, z: 16)** and **left SMG (x: -44, y: -32, z: 24)** taken from previously TMS study on verbal STM (Romero et al., 2006).

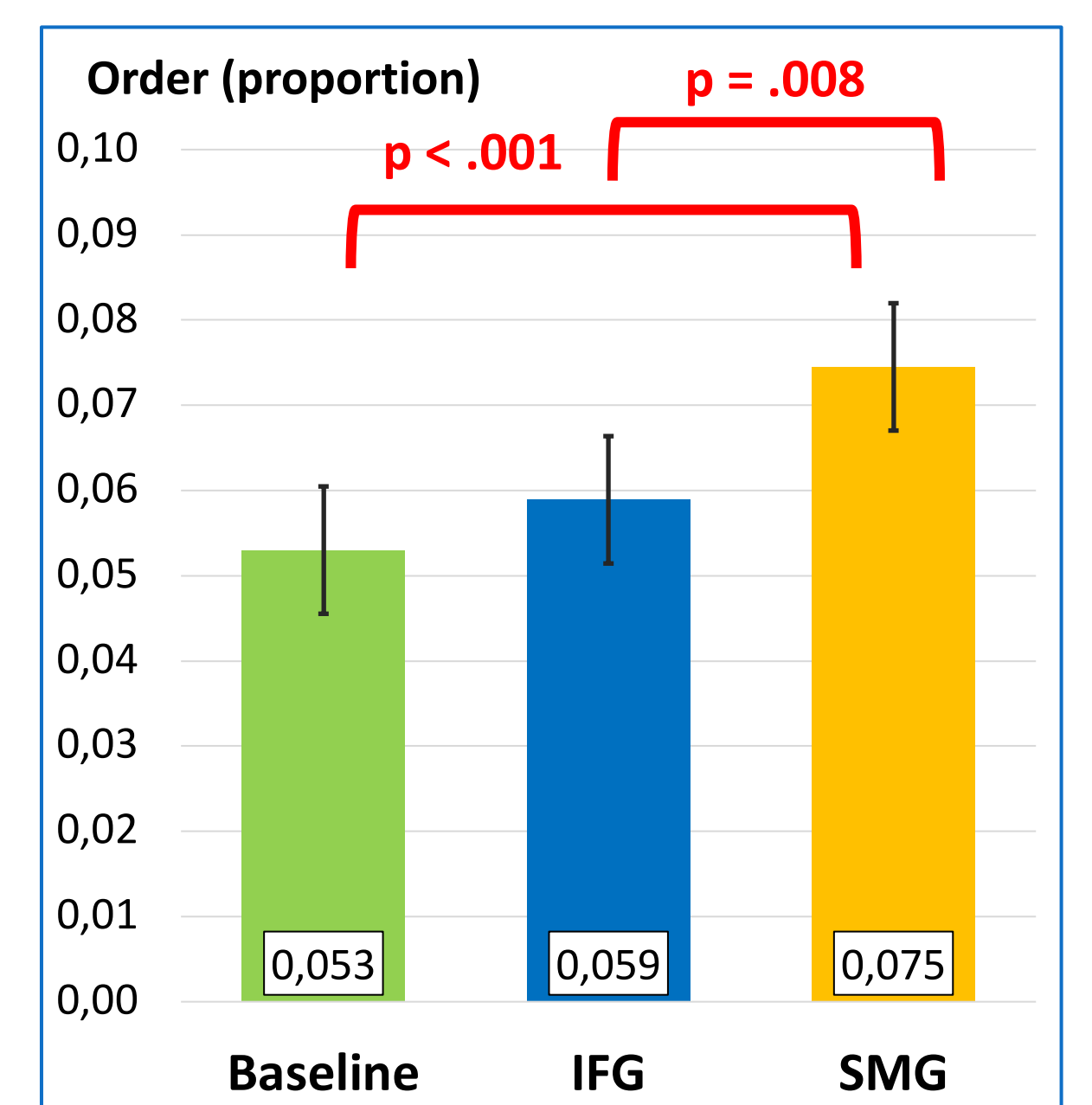
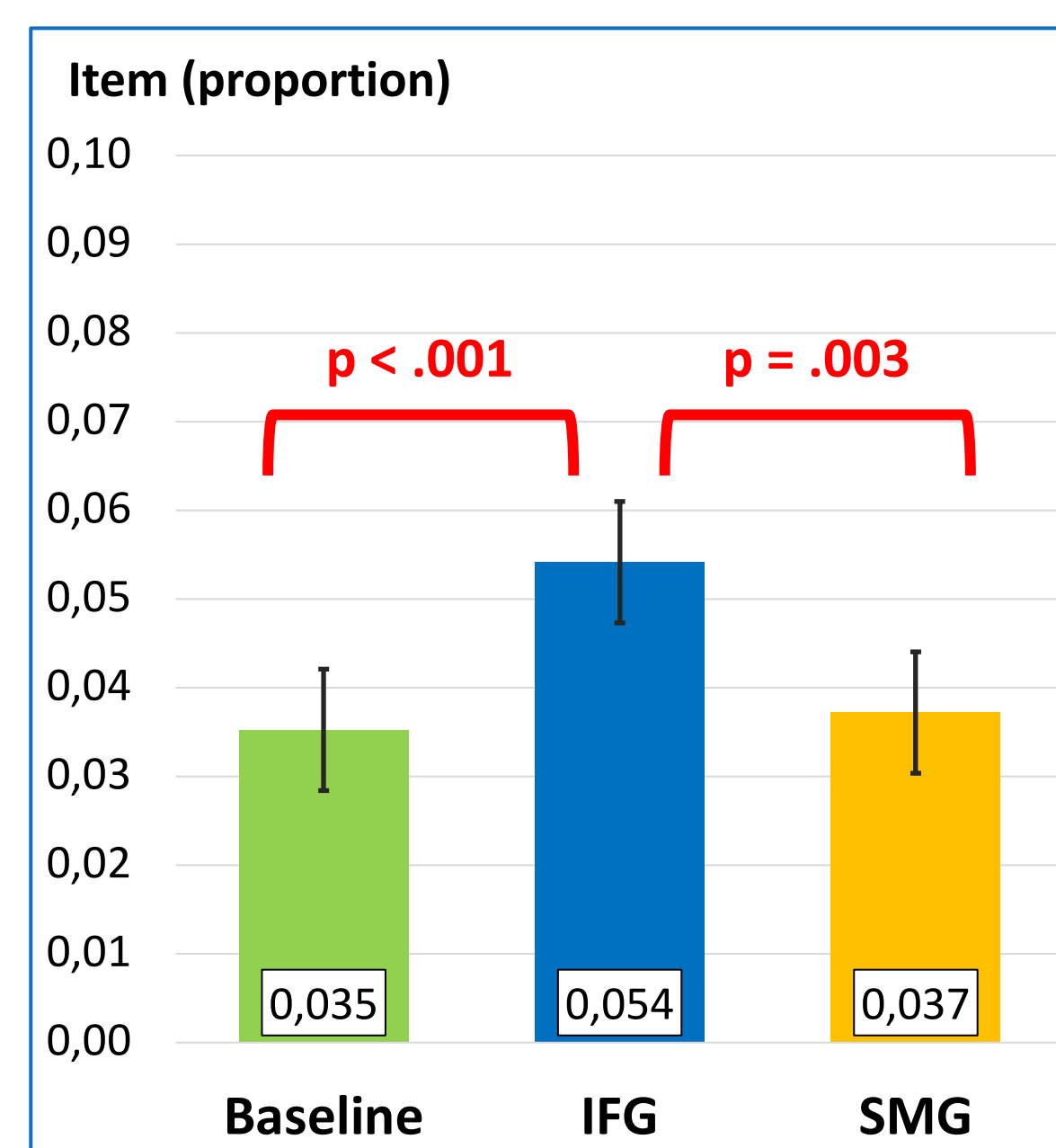
Results

Accuracy

- rmANOVA on accuracy shows that the rTMS of **IFG (68%)** and of **SMG (68%) significantly worsened the performance of the subjects relative to the baseline (74%)** ($p=0.018$).

Error type

- Item and order errors were scored accordingly to St Aubin's scoring method. In detail: **omissions, substitutions and repetitions** → 'item errors' & **inversions and permutations** → 'order errors'. Then, we calculate the proportions of these two types of error. Order errors' proportion was corrected by the span level of the subject, thus because the higher is the number of digits recalled by the subject, the greater the probability to make an order error (St Aubin & Poirier, 1999).
- **rmANOVA on these two types of error shows a significant interaction 'Site of stimulation by Error Type' ($p<0.001$)**. Significant differences from Bonferroni post-hoc comparisons are reported on the graphs.



Conclusion

Our results confirm the hypothesis that, within the cerebral network of verbal STM, IFG and SMG have an anatomo-functional specialization, serving as different mnemonic buffers. In details: **IFG is specialized in the retention of content information** while **SMG is specialized in the retention of serial position information**, thus the inhibition of IFG by means of rTMS causes more item errors while the inhibition of SMG causes more order errors.

Future (and present) directions

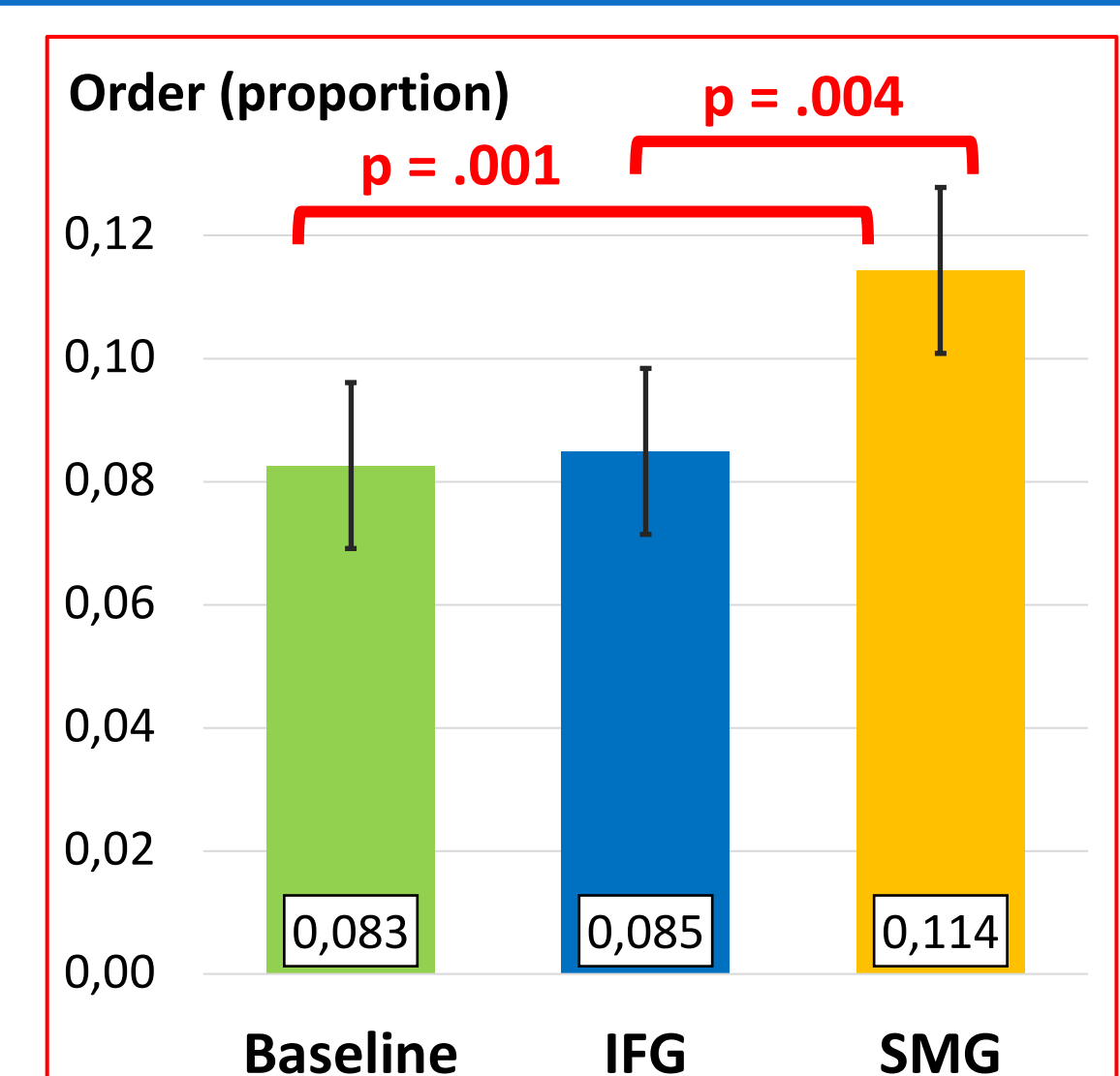
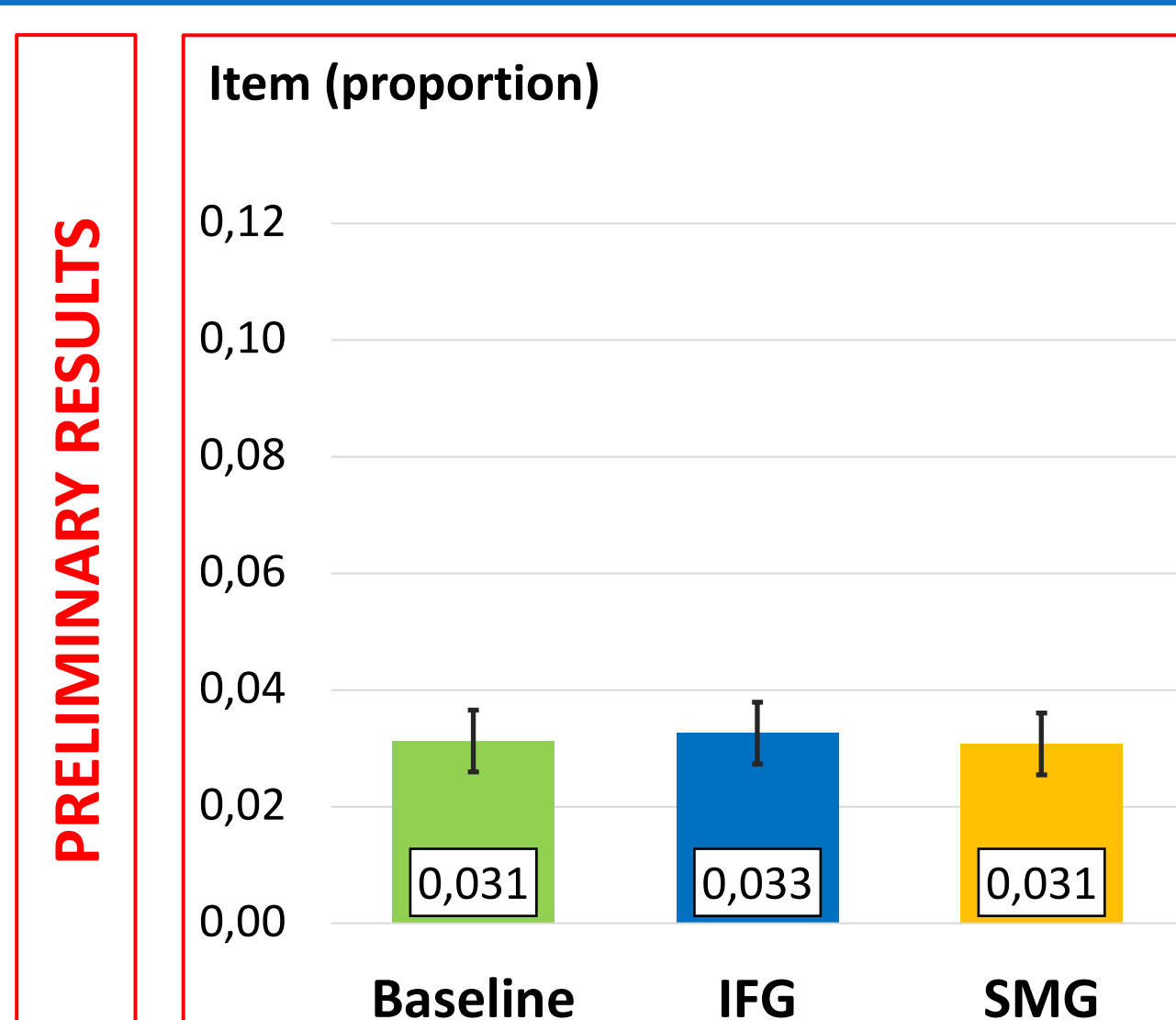
An interesting question arising from this preliminary study is whether **SMG could have a specialization in storing order information regardless from the material type**, as clinical evidence seems to suggest (Papagno et al., 2017).

We are testing this hypothesis in the **Visuo-Spatial STM** domain.

rTMS procedure and sites of stimulation are the same of the verbal experiment while the task is a computerized version of the Corsi block-tapping test (a version similar to the digit span task).

Preliminary results show that the **specialization of SMG in serial order is also present for Visuo-Spatial STM** ($p=0.01$). Conversely, as expected, **inhibiting IFG does not lead to an increase of item errors** ($p=0.976$).

These findings, if confirmed, could lead to new insights about how order information is stored in our brain, expanding the neural substrates of the classic models of STM.



References

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