The role of the supramarginal gyrus and inferior frontal gyrus in working memory: is speech special?

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Introduction

Before meaning can be extracted from a verbal message, acoustical and phonological information needs to be extracted and held in phonological working memory. This complex set of phonological processes is supported by a distributed network of cortical and subcortical regions that includes the anterior supramarginal gyrus (aSMG) and the posterior inferior frontal gyrus (pIFG) [1, 2]. It has been suggested that these two regions are implicated in distinct phonological working memory mechanisms. While the aSMG would temporarily hold phonological information in working memory, the pIFG, in contrast, would serve to refresh phonological information needs to be extracted and held in working memory (i.e., RTs) only during the processing of syllable sequences, while stimulation of these regions during the rehearsal phase disrupts performance (i.e., accuracy) only during the processing of bird song sequences.

Method

Participants
- 18 participants (10 females, 17-35 years old)
- No contraindication to MRI or TMS
- Normal cognitive level (MOCA 29±0.9/30)
- Normal hearing (pure tone audiometry)

Experimental task
- Memory tasks (N-back, Sternberg; Fig. 1)
- Auditory discrimination task with two categories of sounds (bird songs and syllables; Fig. 2)
- Performance measured in terms of RTs and accuracy

TMS equipment
- Super Rapid2 stimulator (Magstim, UK) with neuronavigation system (Brainsight: Rogue Research)
- Surface electromyography electrodes to the right FDI muscle

TMS protocol (Fig. 3)
- Passive motor threshold (MT) (FDI muscle; min. of 50mV, 5/10 trials)
- Stimulation intensity for experiment = 110% of MT(59.7±7.6%)
- Online single pulse TMS to two targets: pIFG and aSMG, at 2 stimulation times (250ms [maintenance phase], 500ms [rehearsal phase]) during the discrimination task
- 384 trials in total including 192 on each site and 48 sham

Analyses
- rANOVA on RTs (i.e. difference between identical and different sequences) and accuracy with target (pIFG, aSMG) and stimulation time as the within-subject factors were conducted for each auditory category (bird songs, syllables)

Results

Preliminary results show that stimulation to the pIFG and aSMG during the maintenance phase disrupts performance (i.e. RTs) only during the processing of syllable sequences, while stimulation of these regions during the rehearsal phase disrupts performance (i.e. accuracy) only during the processing of bird song sequences.

These results suggest that during the maintenance phase, both pIFG and aSMG are involved in the maintenance of phonological information in working memory, whereas during the later phase, these regions would contribute to domain general working memory mechanisms, as bird sequences cannot be rehearsed.

Additional analyses are underway to examine whether the relationship between TMS to the pIFG and the aSMG and auditory discrimination is moderated by working memory capacities.

Discussion

Method

Figure 1. Memory tests

2-back

Figure 2. Auditory discrimination task

Bird songs

Syllables

Figure 3: Target regions

SMG

pIFG

250ms

500ms

Delay 750ms

Figure 4. Audiology (PTA)

Figure 5. N-Back task

Figure 6. Discrimination accuracy

Figure 7. Priming effect

References

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