Exploring the Relationship between Verbal Working Memory and Language Production using fMRI and TMS

Introduction
Perspectives on Verbal Working Memory (WM) Maintenance

Specialized Systems
- WM maintenance activated via language-independent storage systems (e.g., phonological loops, visuo-spatial sketchpad)
- Maintenance of verbal information located in verbal WM is more efficient

Emergent Properties
- WM maintenance activated via temporary storage of long-term perception and action systems
- Same regions of the brain associated with language perception and production also underlie WM maintenance

Present Study: Testing a Language Production-based Locus to WM Maintenance

1. Dissociate Sub-Processes of Language Production
- Language production involves disembedding single words from their semantic context (Jacob & Levelt, 2004)

2. Target the pSTG and MTG for TMS stimulation as people perform language production and memory tasks
- Use stimulus timing context (i.e., on-target) that are delayed relative to speech errors (i.e., phonologically similar)

rTMS Selection and Data Analysis

Selection of rTMS Regions
- Regions were defined on a subject-specific basis, using an uncorrected threshold of p<0.05

Results of rTMS Selection and Data Analysis
- Posterior Superior Temporal Gyrus (pSTG) - phonological encoding
- Middle Temporal Gyrus (pMTG) - lexical-segmenting processing

Delayed Serial Recall

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Results: Reduced Paced Reading

Item Contextual Substitutions
- pSTG: Increased error rate in serial recall and rapid-paced reading
- MTG: Faster speech onset and duration latencies for 1-syllable words

Results: Delayed Serial Recall

Item Contextual Substitutions
- No Effect

Conclusion
1. First study to show a direct, functional relationship between language production and verbal WM maintenance processes

2. Results consistent with the emergent properties perspective on WM maintenance
- Although the type of speech error was different across WM (omission) and production tasks (substitutions), results confirmed that stimulation of regions involved in phonological encoding in production negatively impacts both production and WM tasks

3. Non-specific effects on picture naming tasks merit further research
- This could be a simple orienting response or TMS stimulation using these timing parameter may have been affecting both phonological encoding and lexical-semantic retrieval

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References