The role of the Speech Production System in Auditory Working Memory: A TMS Study

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Background

- **Understanding speech is a complex** process involving both bottom-up and **top-down processing**; the latter of which is particularly necessary in **noisy or unfavourable** listening environments.
- Research suggests that neural activity in non-auditory brain regions, specifically the **speech motor cortex**, may be **advantageous for speech understanding** in challenging auditory environments when speech is degraded [1,2], but in what capacity?
- It is unclear whether speech motor activation reflects 1) the degree of speech degradation, or 2) the increased demands placed on the listeners focus of attention, caused by the background degraded speech.
- Perception of degraded speech involves both **working memory and attention,** allowing the listener to filter-out **and suppress irrelevant** background noise and simultaneously **maintaining target speech** in memory (i.e. selective attention).

Research Questions

- Does speech motor activity during degraded speech reflect **acoustic degradation** or **attentional demands**?
- Is speech motor activity **necessary** for **maintaining** target speech in memory?

Hypotheses

1. If speech motor activity reflects increased demands on attention and memory (*instead of acoustic degradation*), then greater motor activity will be associated with more distracting speech which is least acoustically degraded (*instead of most degraded*).
2. If speech motor cortex contributes to maintenance of auditory information in working memory, then inhibiting speech motor cortex, compared to control brain areas, during speech maintenance will negatively affect retrieval of speech.

References. [1] Nuttall, H. E., et al. Neuroimage 128, 218-226 (2016). [2] Nuttall, H. E., et al. Neuropsychologia 94, 13-22 (2017). [3] Wostmann, M., Lim, S.-J. & Obleser, J. Cereb. Cortex 27, 3307-3317 (2017).

Research Study 1: Degradation or Attention?

Methods

- **Participants (n=24)** were right-handed, monolingual English speakers (mean age = 22.75, sd = 1.74).

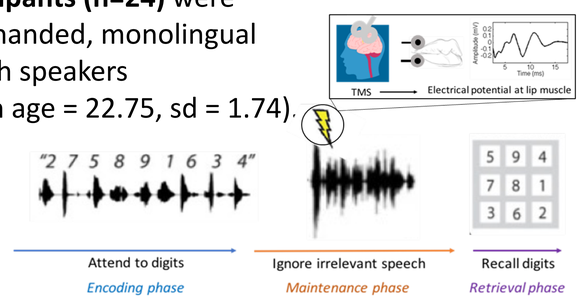

Figure 1. Experimental procedure for Research Study 1

- Participants completed **an irrelevant-speech and forward digit recall task** [3], see Figure 1. **Prior to recall**, participants heard **irrelevant speech degraded** using 3-levels of noise vocoding, and received a **single pulse of TMS**. TMS was administered at **120% of aMT to the lip area** of primary motor cortex. MEPs recorded from the contralateral lip.

Results

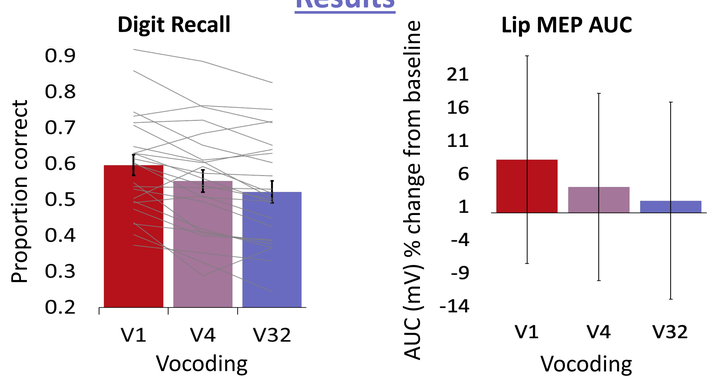

Figure 2. Left. The proportion of correctly recalled digits at each vocoding level. Right. The mean baseline corrected (% change) AUC values for lip MEPs.

- A repeated-measures ANOVA showed a **significant effect of degradation on digit recall** ($p < .001$, n=24). Although this behavioural effect was **not significantly reflected in the magnitude of MEPs** ($p < .55$, n=20).

Conclusion

- Distracting speech (less acoustically degraded) is associated with poorer digit recall, but not greater speech motor activity. These data do not support the hypothesis that speech motor activity reflects attentional demands.

Research Study 2: Speech Motor Cortex Inhibition

Methods

- **Participants (n=8)** were right-handed, monolingual English speakers (mean age = 20.38, sd = .52).

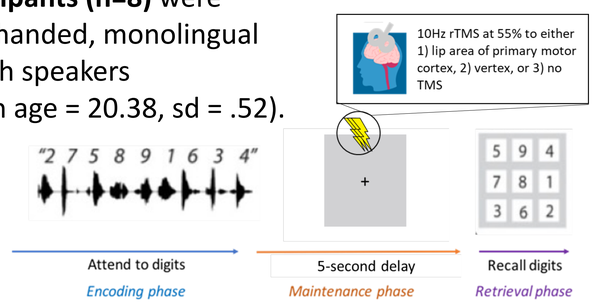

Figure 3. Experimental procedure for Research Study 2

- Participants completed a **forward digit recall task**, see Figure 3. Prior to recall, participants received **10Hz rTMS at 55% intensity** to either the **lip** area of primary motor cortex, the **vertex**, or received **no TMS**.

Results

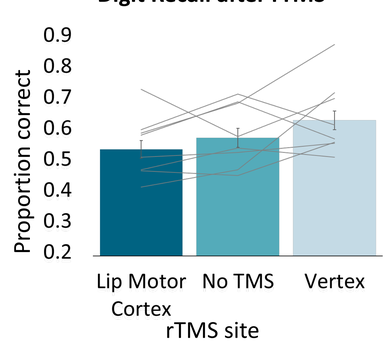

Figure 4. The proportion of correctly recalled digits in each rTMS condition

- A repeated-measured ANOVA showed that **rTMS condition did not significantly affect digit recall** ($p = .122$).

Conclusion

- Maintaining auditory working memory is not affected by inhibition of articulatory motor cortex; indicating that activity in this area is not necessary for this process. However, descriptive data indicate that digit recall was lowest following rTMS to lip area (mean=.54), compared to no rTMS or vertex rTMS (means=.58, or .63).
- However, definitive conclusions can not be drawn due to the small sample size, which can only provide us with interim indications as data collection is still ongoing.