The Use of Real Time MRI in the Assessment of Articulatory Outcomes of Partial Glossectomy

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1 Introduction

I. Real-time MRI as exciting new imaging tool
   - A. Safe imaging protocol
     - i. Non-ionizing radiation
     - ii. Non-invasive measurements
   - B. Provides rich data sets
   - C. Allows task-specific customization
     - i. Can customize the trade-off between:
       - a. Spatial Resolution
       - b. # Slices Acquired
       - c. Temporal Resolution
   - D. Allows concurrent global imaging of vocal tract

II. Current study details
   - A. Patient: Advanced stage basal tongue cancer
   - B. Operation: Partial glossectomy (cancerous tissue resection)
   - C. Provides relatively controlled manipulation of vocal tract
     - i. Non-operated articulators are unaffected
     - ii. Patient cognition remains largely unchanged
   - D. Provides good opportunity for controlled research questions
     - i. Here we explore how morphology (and its changes) influence articulator synergy
     - ii. Controls other factors to observe change in synergy due to change in morphology

III. Current work's aims:
   - A. Pre-op and post-op data allow quantification of morphological changes
   - B. Vocal tract dynamics allow estimation of articulator synergies
   - C. Observation of relationship between morphology and synergies

IV. Methods allow future examination of:
   - A. Individual variability in articulator synergies
   - B. Relationship of morphological change and compensation
   - C. Individual variability in degree of plasticity
   - D. Relationship of accommodation to functional outcome
   - E. Use of feedback to monitor articulatory task goals

2 Methods

I. Participant: Male speaker of British English

II. Scan format and time course:
   - A. Pre-op scan just prior to surgery
   - B. Post-op scan 6 months after surgery (when intelligibility plateaus)
   - C. Participant supine with motion minimized
   - D. Reading 30 second passages of scripted speech

III. Stimuli:
   - A. Numerous repetitions collected during both preop and postop sessions
     - i. Monosyllabic (bVt) words
     - ii. Rainbow passage
     - iii. MOCHA-TIMIT sentences

IV. Imaging:
   - A. Scanner: 1.5T GE Signa Excite HD
   - B. Max gradient amplitude: 4.0 G/cm
   - C. Max slew rate: 15.0 G/cm/ms
   - D. Transmission: body coil
   - E. Reception: 8-channel upper airway coil

V. Data:
   - A. FOV: 200x200mm
   - B. Slice thickness: 6mm
   - C. Flip angle: 15°
   - D. Spatial resolution: 2.38x2.38mm
   - E. Temporal resolution: 11ms preop, 12ms postop

VI. Pre-processing:

A. Air-tissue boundary segmentation

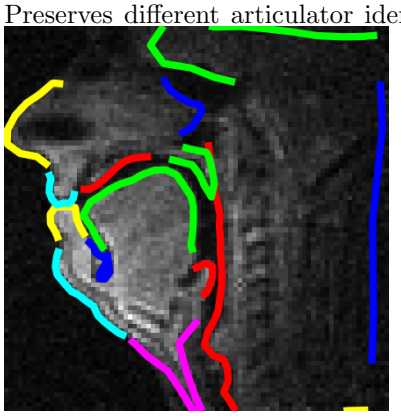
i. Unsupervised algorithm

ii. Provided anatomic template

iii. Hierarchical gradient descent optimized fit

iv. Produces polyline vocal tract outline

v. Preserves different articulator identities:



VII. Analysis:

A. Population sub-sampling:

i. Necessary due to data paucity

ii. Allows drawing meaningful conclusions from sample differences

iii. 5 iterations of random bisection and comparison

iv. Produced 20 sub-samples (5 iterations x 2 halves x 2 data-sets)

B. Guided factor analysis:

i. Allowed isolation of articulator contributions

ii. Quantified levels of tongue and jaw activation in coordinated tasks

iii. Quantification allows synergy calculations

iv. Changes in synergies pre- vs. post-op show compensation in articulatory strategies

VIII. Forward map estimation:

A. Relies on task dynamics

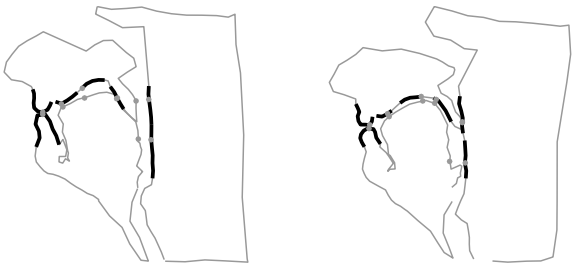
i. Defines speech goal as constriction formation

ii. Constriction degree and location change for different speech tasks

B. Calculates constrictions from segmentation data

C. Each frame's constrictions can be made by weighting and summing articulator factors

i. Weights represent degree of utilization of that factor



D. Relationship of weights to constrictions is mapped forming weight sequences

E. Weight sequences represent articulatory strategy and can reveal articulatory differences

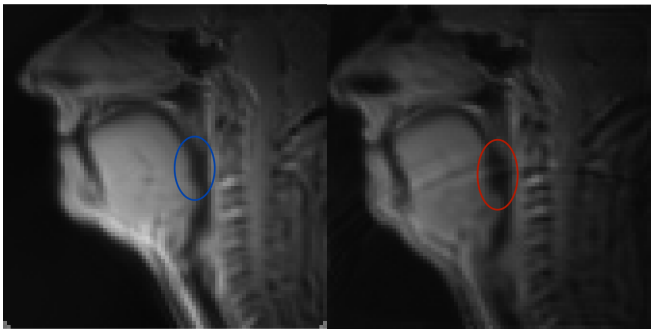
F. Simulations of varying tasks

i. Utilizes aforementioned forward map

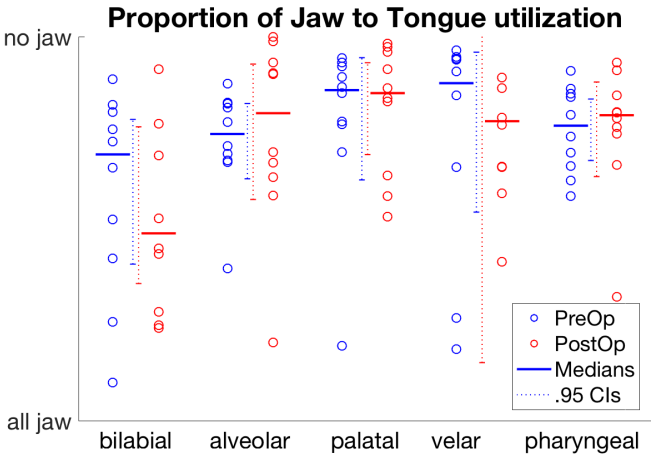
ii. Reveals differing articulatory strategies between forward maps

3 Results

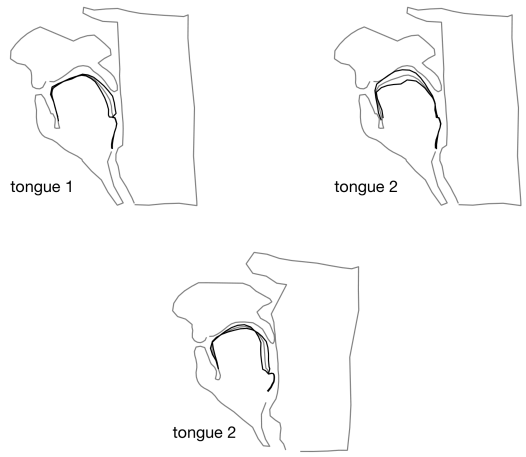
I. Static vocal tract outline reveals tongue volume decrease basally in post-operative images



II. We observe no systematic difference in articulatory synergy, therefore we find no evidence for compensation



III. We do see a difference in pre- vs. post-op factors, implying a difference in articulatory behavior



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