Compensatory Speech Mechanisms Following Oral Tongue Resection

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Background
- Oral and pharyngeal cancers impacted 45,849 individuals in 2018.1
- Treatment options: glossectomy or hemi-glossectomy, radiation, chemotherapy.
- Impacts speech production and swallowing.2

Post-operative speech production:
- The tongue is the major oral articulator. In its absence, speech production is altered.
- Intelligibility may be impacted.
- Patients may compensate in order to produce certain target consonants.

Typical speech segment production:
- Alveolar: tongue tip and alveolar ridge (Fig. 1)
- Interdental: tongue tip and teeth (Fig. 1)
- Alveopalatal: tongue tip and area directly posterior to the alveolar ridge and anterior to the palate (Fig. 1)
- Velar: tongue dorsum and velum (Fig. 1)

Real-time magnetic resonance imaging (rtMRI):
- Allows for viewing of the entire vocal tract during speech production.

Objective
To identify which sounds are and are not compensated for by an individual who underwent treatment for oral cancer.
- What compensatory mechanisms are exhibited post-operatively, and how do these vary across target type? (Fig. 1)

Hypotheses
Surgical treatment will impact production of anterior speech segments post-operatively.
- Alveolar, interdental, and post-alveolar segment production is likely to be affected.
- Velar segment production is likely to remain largely intact.

Specific predictions:
- Alveolar segments (e.g., /t/): Rather than the tongue tip constricting at the alveolar ridge, constriction may be formed using other parts of the tongue or the lips.
- Interdental segments (e.g., /θ/): Rather than the tongue tip being placed between the teeth, frication may be created using other parts of the tongue or the lips.

Hypothesis (cont’d)
Specific predictions (cont’d):
- Alveopalatal segments (e.g., /j/): Rather than the tongue tip forming constriction in the alveopalatal region, constriction may be formed using other parts of the tongue or the lips.
- Velar segments (e.g., /k/): The tongue dorsum will constrict at the velum.

Methods
Participant:
- 70-year-old male who underwent radiation treatment and hemi-glossectomy for oral tongue cancer (Fig. 2).
- Reconstructive forearm flap was sutured to residual tongue.

Stimuli:
- The TIMIT Corpus5
- The Rainbow Passage2

Data Collection:
- Image data: rtMRI scan (~23 f.p.s.)
- Acoustic data: Collected simultaneously and noise-cancelling

Data Analysis:
- MATLAB GUI
- Audio and video files were inspected simultaneously.
- Image data analyzed frame by frame to determine the location of the articulators during maximum constriction.
- Data organized based on target segment type.
- Patterns in compensatory strategies identified.

Results
Speech segments for which compensatory behaviors were observed:
- Alveolar segments
- Interdental segments
- Alveopalatal segments

Unaffected speech segments:
- Velar segments

Compensatory mechanisms used:
- Articulations that typically take place in the anterior oral cavity moved posteriorly.
- In some cases, target alveolar stops (/t/, /d/) involving closing the lips in addition to the tongue body, whereas other alveolar segments (/l/, /r/, /n/) did not.

Future Directions
- Investigate effectiveness of compensatory mechanisms with respect to intelligibility.
- Increase sample size.
- Investigate the presence of a nasal quality in speech.

Clinical Implications
- Post-operative patients would likely benefit from receiving intervention to learn adaptive methods that focus specifically on creating compensatory mechanisms.
- Training of compensation should focus on segments produced by particular parts of the tongue that are impaired post-operatively.
- Compensatory behaviors that preserve maximum acoustic/ perceptual contrast should be prioritized.

Selected References
4Speech Sounds Disorders/Articulation and Phonology. (n.d.). American Speech-Language-Hearing Association | ASHA.