Intrinsic laryngeal muscle activity in response to sympathetic nervous system activation

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Amanda I. Gillespie, M.S.
Erin Glass
Neil Szuminsky, M.S.
Robin Ashmore, Ph.D.

Background & Introduction

Voice Stress

Fear

Introversion

Extroversion

Anxiety

Possible brain-larynx pathways

HPA axis
Somatic motor system
Autonomic nervous system

Dietrich (2008) summarizes the combined laryngeal effects of these three systems
- Decreased blood flow
- Decreased mucosal secretions
- Increased muscle tension

The autonomic-voice link

Larynx in isolation ≠ voice
- Voice literature replete with references to the voice-ANS link
- Larynx has clear sympathetic and parasympathetic innervation...
  - ...but is not “classically” considered part of ANS
  - ...but its role in valving for pulmonary system not discussed as it relates to ANS response
- Little understanding of functional laryngeal response to ANS activation
Present Study

- Primary research question: *How does a whole-body autonomic response manifest in the larynx?*
  - Hypothesis: Intrinsic laryngeal muscles will exhibit elevated activation at rest, during and following an experimentally elicited SNS response

Experimentally eliciting SNS response

- Several options
  - Cold pressor task
  - Mental arithmetic
  - Stroop (i.e., Color-Word Interference test)
  - Public speaking preparation
- All options produce robust [classically] sympathetic responses
  - Cardiovascular
  - Peripheral muscles
- Cold pressor task is only non-linguistic task

Present study

- Secondary research question: *Does subvocalization occur at the level of the larynx during minimal-stress cognitive tasks with linguistic underpinnings?*
  - Hypothesis: Greater activation of ILMs will be observed during silent reading and counting tasks relative to a state of rest.

Participants

- n=8 vocally normal females
- Negative history of
  - Voice disorders
  - Neck or throat surgery
  - Asthma
  - Blood clotting disorders
  - Depression, eating disorders, panic disorders, anxiety disorders
  - Dysautonomia
  - Current pregnancy, upper respiratory illness, allergies
Study Procedures

1. Place non-invasive equipment
   - blood pressure cuff
   - electrodes for EKG
   - EMG of trapezius, submental complex

2. Place fine-wire electrodes
   - right PCA
   - bilateral TA/LCA
   - bilateral CT

3. Guided relaxation
   Verify heart rate and blood pressure return to baseline

4. Laryngeal electromyography (LEMG) baseline patient at rest, supine, for 90 seconds

5. Subvocalization task
   - read (30 sec)
   - count backwards from 100 by 1 (30 sec)

6. Experimental task
   SNS activation via cold pressor task. Hand plunged into ice water (34.08º, SD 0.79º) for 3 minutes.

7. Verify placement
   - PCA: sniff
   - TA/LCA: valsalva
   - CT: pitch glide
   - Submental: swallow

8. Repeated LEMG baseline patient at rest, supine, for 90 seconds

9. Repeated Cold Pressor Task
   n=3 elected to repeat cold pressor task

Successful LEMG placement

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Live (audio-visual)</th>
<th>Begin Experiment (visual)</th>
<th>End Experiment (visual)</th>
<th>Total</th>
</tr>
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<tbody>
<tr>
<td>Right PCA</td>
<td>8</td>
<td>4</td>
<td>6</td>
<td>4</td>
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<tr>
<td>Left TA/LCA</td>
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<td>Right TA/LCA</td>
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<td>Left CT</td>
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<td>Right CT</td>
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</table>

Analysis

- Z-scores calculated using interrupted time-series analysis (ARIMA, statistics module) performed in Matlab
- Findings significant at p < .05
### Results: Baseline vs. CP (1st 90 seconds)

<table>
<thead>
<tr>
<th>ID</th>
<th>EKG</th>
<th>SUB</th>
<th>TPZ</th>
<th>PCA</th>
<th>LTA</th>
<th>RTA</th>
<th>LCT</th>
<th>RCT</th>
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Arrows indicate significance at α < 0.047. Hash marks indicate no significant findings. Shaded blocks indicate discarded channels.

### Results: Repeated cold pressor task

<table>
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</table>

Black symbol – comparing original LEMG to CP
Red symbol – comparing original LEMG to repeated CP

Arrows indicate significant at p < .05, and direction of change; Hash marks indicates no significant findings

### Results: LEMG versus Subvocalization

<table>
<thead>
<tr>
<th>PCA</th>
<th>LTA</th>
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### Conclusions

- Evidence of functional autonomic response of the larynx
  - Overall, increased activation as a function of cold pressor task
  - Concomitant activation of adductory and abductory muscles
  - Somewhat more variable cricothyroid response
- Evidence of “laryngeal subvocalization” as a function of cognitive task with linguistic underpinnings
  - Highly variable findings within and across subjects
    - Must consider that non-verbal reading or math tasks may have triggered some level of anxiety or stress
    - Residual laryngeal activation from needles?
    - Self-soothing behaviors?
Considerations

- In functional voice impairment, what else is at play?
- Can less-invasive proxies really provide good estimation of laryngeal muscle tension?
  - Surface EMG
  - Laryngoscopy
  - Palpation
- How do interpersonal stressors affect the degree and pattern of muscle tension in the larynx via the ANS?
- Responses in this study may have been influenced by parasympathetic response

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