An acoustic and perceptual analysis of adaptation to an EPG artificial palate

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Electropalatography

- Has provided valuable insights into the dynamics of tongue-palate articulation in children and adults

- Shown positive treatment outcomes for children with articulation disorders (Carter & Edwards, 2004; Gibbon et al., 1993; 2003)

- Requires the use of a thin acrylic artificial palate:
  - Resembles an orthodontic retainer
  - Generally accepted by EPG researchers that between 45 minutes and 3 hours required to *adapt* to the presence of the palate (Goozee et al., 2003; Hardcastle et al., 1991; McAuliffe et al., 2001)

- Few detailed comparisons of speech prior to, and following, palate insertion → this practise has attracted recent criticism (Weismer & Bunton, 1999)
Effect of a dental prosthesis – An overview

- Acoustic and perceptual studies have reported a lack of adaptation using thicker palates and, generally, shorter desensitisation times:
  - McFarland et al. (1996): Retainer lowered by 3mm and 6mm in alveolar-palatal region – 15 mins of adaptation
  - Hamlet and colleagues (1978; 1979): Retainer 1mm and 4mm thick in alveolar region – increased adaptation times

- Recent perceptual and acoustic evidence to the contrary
  - Searl et al. (in press): Employed a 1mm thick dental appliance which covered palate and teeth.
  - Reported perceptual and spectral evidence of adaptation to the presence of the prosthesis following approximately 45 minutes
  - Study examined /t/ and /s/ production only
Adaptation to an EPG palate

- Individuals are considered to have adapted when:
  - Speech articulation observed by the examiner to have returned to a similar level of articulatory precision as without the palate in-situ
  - Excess salivation has ceased

- Recent anecdotal reports of the palate negatively influencing speech production in adults – particularly /s/ (McAuliffe et al., 2006a; 2006b)

- Preliminary study supported these reports, finding changes to both temporal and spectral features of consonant articulation in three normal speakers following palate insertion (McAuliffe et al., submitted).

- However, study exhibited small participant numbers, limited range of consonants investigated, and examination of consonants only
Aims and Hypotheses

- **Aim 1:** Examine the effect of an EPG palate upon speech production using perceptual, temporal, and spectral measures

- **Aim 2:** Determine if currently used adaptation times result in articulation returning to “no palate” or baseline level

- Two possible outcomes:
  - The palate will have little effect on selected measures of articulation following a period of adaptation
  - OR
  - The palate will have discernable effects upon articulation across some or all of the sampling periods
Participants and Method

- Eight young adult females (mean age = 24 years)

- Exhibited normal dental occlusion and reported no history of orthodontic treatment or neuromotor, speech, or hearing disorder

- Received a custom made “practise palate” – contains no electrodes or lead wires

- Speech production examined under four experimental conditions:
  (1) prior to insertion
  (2) immediately following insertion
  (3) 45 minutes post-insertion and
  (4) three hours post-insertion
Recording and Stimuli

- All speech recorded using a Sony Digital Audio Tape (DAT) recorder and a uni-directional microphone (Sony ECM-3)

- Five repetitions of the experimental stimuli examined in a CVC context following a schwa:
  - a teat - a keep - a seat - a sheep
  - a tart - a cart - a saab - a sharp
  - a toot - a coop - a suit - a shoot

- Perceptual, temporal, and spectral analysis of the stimuli was conducted
Perceptual Analysis

- A sample of the experimental stimuli was selected for analysis.

- The third repetition of five was selected → resulted in a total of 461 samples for rating (including 20% for reliability).

- Computerised perceptual speech analysis program randomly generated and played participants speech samples (O’Beirne & McAuliffe, 2005).

- Seven naïve listeners, undergraduate students, rated consonant precision on a scale of 0 (normal precision) →10 (severe imprecision).
Acoustic Analysis

- Temporal analysis (amplitude-by-time display)
  - Consonant duration
    - Stops: voice onset time (ms)
    - Fricatives: duration of aperiodicity (ms)
  - Vowel duration: onset to offset of periodicity at level of 1st formant

- 1st and 2nd formant frequencies: Measured over a 50ms mid-point of the vowel steady state

- Mean spectral energy:
  - Stops: a 20ms section of the consonant was selected beginning at the onset of the burst
  - Fricatives: 50ms window as positioned at the midpoint of the consonant
Perceptual Results: Collapsed across sounds

Consonant precision
0 = normal, 10 = severe imprecision

- t=6.57, p<0.001
- t=3.34, p<0.01
- t=1.48, p>0.05
Acoustic Results – Vowel Duration

No significant differences in vowel duration across conditions
Acoustic Results – Consonant Duration

A significant increase in duration of /sh/ between the immediate and 45 minute conditions only (q=4.38, p<0.05).

All other comparisons non-significant.
Acoustic Results - F1 and F2

No significant differences in F1 or F2 values across conditions
Acoustic Results – Mean spectral energy

Significant reduction in mean spectral energy for /s/ between the pre and immediate, 45 minute, and 3 hour conditions.

All other comparisons non-significant.
Discussion

- Following three hours of adaptation, naïve listener’s ratings had returned to baseline → a period of three hours of adaptation preferable for EPG investigations.

- Temporal measures were not affected by the insertion of the artificial palate → possible that participants exhibited conscious control over segment duration, compensating for the changed articulatory conditions.

- Vowel formants were not altered by presence of palate → possible that participants had greater jaw lowering to maintain perceptual quality of vowels.
Discussion

- Spectrally, results indicated that the palate negatively affected /s/ articulation. It is likely that two factors are responsible for this finding:
  (1) The high level of lingual precision required for /s/ production
  (2) Articulation in the alveolar region of the palate

- Limitations of the present investigation: Small participant numbers and examination of adaptation in single word context only.
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References


