THE ULTRAPHONIX PROJECT: ULTRASONIC VISUAL BIOFEEDBACK FOR HETEROGENEOUS PERSISTENT SPEECH SOUND DISORDERS

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BACKGROUND

- Ultrasound Visual Biofeedback (U-VBF) shows promise as a technique for the remediation of persistent Speech Sound Disorders (SSDs).1
- U-VBF allows the surface of the tongue (Fig 1) to be imaged in real time and used as a biofeedback device in a motor-learning paradigm.
- Many current studies focus on the remediation of /r/ or North American dialect ultrasound being useful for imaging most lingual consonants and all vowels.
- Most current studies use a hand-held ultrasound probe and thus do not report on diagnostic information and phonetic insights gleaned through recording of high-speed ultrasound.

AIMS

- The UltraPhonix project extends previous research by trialing U-VBF with a range of SSDs and by collecting high-quality headset stabilised ultrasound. Our research questions are:
  1. Does U-VBF improve accuracy of the targeted phonemes in untreated worldlings?2
  2. Does U-VBF treatment improve intelligibility outside of the clinic environment?
  3. Do children with intractable SSDs show speech errors which are phonetically different from typical developing children? That is, do children with SSDs display tongue-shapes rarely seen in typical children which may therefore be indicative of abnorm al development?

ANALYSIS

- Data is acquired at each assessment and therapy session.
- Six untreated assessment probes (grey boxes) are prioritised for ultrasound and perceptual analysis.
- Ongoing annotation of the therapy target and any minimal pairs. For example, for children who are persistently velar fronting, the burst of /r/ /s/ in all words and /n/ /d/ from suitable minimal pairs are annotated.
- Splines are exported to the AAA Workspace for qualitative analysis and co-ordinates are exported for quantitative analysis of differences in tongue shape.

Example Ultrasound Results: 04M

Perceptual Analysis

The DEAP phonology subtest and probe wordlists are transcribed by a phonetician blind to the diagnosis of each child and to the intervention time point:
- DEAP is scored for % consonants correct (PCC)
- Probes are scored for % treated segment correct (PTCC or PCC)

For example, if velars are treated, the number of correct-sounding /i, /s/ (i.e., phonetically accurate) velar stops from a 105 item list are presented as a % PCC.

Preliminary Results: First Cohort

- Six children completed or near completion.
- Table (below) shows the age of the children and the phonological/phonetic pattern targeted in therapy alongside the number of sessions required to learn the new articulation.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Sex</th>
<th>Age</th>
<th>Target</th>
<th>First New Articulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>F</td>
<td>8.8</td>
<td>Velar fronting</td>
<td>Session 2</td>
</tr>
<tr>
<td>02</td>
<td>F</td>
<td>7.8</td>
<td>Cluster Reduction</td>
<td>Session 1</td>
</tr>
<tr>
<td>03</td>
<td>F</td>
<td>10.11</td>
<td>Velar fronting</td>
<td>Session 2</td>
</tr>
<tr>
<td>04</td>
<td>M</td>
<td>7.2</td>
<td>Velar fronting</td>
<td>Session 1</td>
</tr>
<tr>
<td>05</td>
<td>M</td>
<td>6.5</td>
<td>Vowel Disorder</td>
<td>Session 1</td>
</tr>
<tr>
<td>06</td>
<td>M</td>
<td>6.4</td>
<td>Post-Alveolar fronting</td>
<td>Session 4</td>
</tr>
</tbody>
</table>

PARTICIPANTS and DESIGN

Ultrasound Setup

- Ultrasonic SonarSPLIT machine: C9-5/10 probe
- Articulate Assistant Advanced software™1
- 1211ps with a 112.5 degree field of view (FOV)
- Fig 1 (right) shows a typical ultrasound image (right)
- Headset (Fig. 1, left) used to stabilize the ultrasound probe during assessments and therapy.

Simultaneous acoustic and lip-camera recordings

PROTOCOL

Participant Referred from Speech & Language Therapist

Assessment

- Speech: Diagnostic Evaluation of Articulation and Phonology (DEAP): Phonology & Articulation Subtests
- The Intelligibility in Context Scale (IC5)

Target Selection

- DEAP: Phonetic and phonological process analysis performed. Commonest systematic error (developmental /r/ errors expected) identified and untreated Probe wordlist identified

Therapy

- 10 Sessions of U-VBF
- Motor-based therapy, beginning with elicitation of the new articulation in a facilitative coarticulatory context:
  - Beginning with level 0, the child progresses to the next level only when he/she is able to produce 8/10 tokens at that level correctly.

Post-Therapy Maintenance: Untreated Probes, DEAP Phonology & IC5

3 Months Post-Therapy Maintenance: Untreated Probes, DEAP Phonology & IC5

CONCLUSIONS

- Ultrasound Visual Biofeedback shows promise as both a diagnostic tool and motor-based speech therapy in children with persistent Speech Sound Disorders.
- Results so far show rapid acquisition of new articulations in the first few sessions (mode = session 1) but slower generalisation to untreated words.
- Ongoing ultrasound analysis is also providing evidence of a range of abnormal tongue shapes (for example undifferentiated lingual gestures) suggesting a motoric cause of persistent speech sound disorders, even in children with pre-existing diagnoses of “phonological disorder”.

References