Speech production: disordered EPG data

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aims of lecture 2

- recognise EPG patterns produced by those with speech disorders
- appreciate how EPG can be used in speech therapy for diagnosis and therapy
EPG studies on clinical applications
(N = 148)

EPG studies on clinical applications

• 148 clinical studies (400+ in total) on a wide range of speech pathologies
• most commonly studied pathologies are cleft palate and functional articulation disorders
• most report diagnosis, < half report therapy
• most study school age children 5-18 years
• most report small groups of <5 speakers
EPG as a diagnostic tool

• all studies agree that EPG is only useful when used in addition to other diagnostic techniques, instrumental and perceptual
• all show that EPG can provide clinically relevant information not readily available from other assessment procedures
• review identified a variety of ways in which EPG contributes to speech assessment
next sections describe how we can ... 

• identify abnormal patterns of tongue palate contact in children with cleft palate
• detect covert contrast
pattern 1

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EPG patterns during word-initial /t/ in 'a top' produced by 8-year-old boy with cleft palate
pattern 2

target /t/ in ‘a top’ produced by 14-year-old girl with a cleft palate
pattern 3

target /æ/ in ‘a shoe’ produced by 7-year-old boy with cleft palate heard as a lateral fricative [ɹ]
pattern 4

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Target /i/ in ‘seat’, produced by a 9-year-old girl with a cleft palate
pattern 5

target /d/ in 'ladder', produced by a 8-year-old boy with history of velopharyngeal incompetence
### pattern 7

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#### Adult (normal)
- VI = 3.2

#### Child (normal)
- VI = 12

#### Child (cleft palate)
- VI = 21.71

Variability index (VI) values for the frame of maximum contact over five repetitions of /ɔ/. Maximum VI = 50. Shading indicates frequency of electrode contact (maximum = 5).
Unusual articulations ...

• case study of a child who used clicks as compensatory articulations
clicks as compensatory articulations

- almost nothing in the literature
- an observation: “on rare occasion we have observed click substitutions of stop consonants in children with VPI” (Peterson-Falzone, Hardin-Jones and Karnell, 2001, p. 170)
- single case: 6-year-old with cleft palate used bilabial clicks [ɗ] for /p/ targets (Howard, 1993)
click production

- only occur in the languages of Southern Africa
- essential component is “the rarefaction of air enclosed between two articulatory closures formed in the oral cavity” (Ladefoged & Maddieson, 1996, p. 246)
- complex speech segments involving the co-ordination of the tongue tip with the tongue dorsum
- 5 different types of clicks, e.g. alveolar [ǃ], alveolar lateral [ǀ], bilabial [letal]
stages of click production

- 1\textsuperscript{st} phase: traps a pocket of air between an anterior and a posterior closure
- 2\textsuperscript{nd} phase: involves the cavity between the two closures enlarging, so air in the pocket is rarefied and pressure drops
- 3\textsuperscript{rd} phase: anterior closure is released, with a sudden rush of air into the mouth producing a click
1. Tongue tip up to form front closure

3. Tongue tip lowered so that air rushes into the mouth

2. While both the anterior and the velar closure are maintained, the body of the tongue moves down decreasing the pressure of the air in the front part of the mouth

4. Velar closure released

1. Back of tongue raised to form velar closure

From Ladefoged (1997)
EPG and clicks

- EPG good technique to investigate clicks
- no previous EPG studies about clicks as abnormal articulations
- some EPG studies of clicks in African languages (Thomas, 1997, 2000)
case study

- Scottish-speaking 14-year-old girl with VCFS
- ongoing VPI
- normal palatal arch
clicks

- /d/, /k/ and /g/ targets were alveolar clicks [!]
- produced fluently in all word/syllable positions

/g/ “baby Gary’s got a bag of lego”

/k/ “happy Karen is making a cake”

/d/ “my daddy mended a door”
EPG data

target /k/ in “Karen”
timing measures
similarity with African clicks

• these are definitely clicks, as verified by a world expert in click languages
• they sound similar to African clicks (Traill, 1985; Thomas, 1997; Ladefoged & Maddieson, 1996)
why use clicks?

• a strategy to “capitalise on negative pressure for the production of plosion” (Peterson-Falzone, Hardin-Jones and Karnell, 2001, p. 170)

• VPI makes it impossible to build oral pressure using a normal pulmonic airstream

• use of a velaric airstream allows plosion to be achieved in the presence of VPI
why use clicks?

• supporting evidence: when clicks eradicated in therapy they were replaced with weak plosion

My Daddy mended a door (clicks)

My Daddy mended a door (weak plosion)
complex articulations

- clicks are rare, BUT other complex articulations involving velar closure are frequent in cleft palate
- other 2 types are: alveolar-velar and labial-velar double articulations
relationship with other complex articulations?

- perhaps double articulations with velar closure also capitalise on negative pressure to produce plosion?
- might occur prior to palatal surgery or where there is ongoing VPI
covert contrasts

• what are they and why are they important?
covert contrast

- phonological contrasts produced in subtle ways that listeners do not hear
- identified in speech of individuals with disorders - children and adults
- we cannot assume that phonological processes result in loss of contrast (i.e. neutralisation)
loss of contrast

- phonological processes do not always result in loss of contrast at the phonetic level
- acoustic evidence of covert contrast (Maxwell & Weismer 1982; Forrest & Rockman 1988; McLeod & Isaac 1995)
- EPG evidence of covert contrast (Gibbon, 1990; Gibbon et al, 1999)
acoustic data - cluster reduction

- boy (7;2) articulation disorder (Weismer 1981)
- obstruent interval 60 ms longer for reduced cluster [k] than singleton [k]

/k/ target realised as [k]  /sk/ target realised as [k]
covert contrast revealed by EPG data

- DL, (male 9), velar fronting (unpublished data)

/t/  $\overline{\times}[t]$
/k/  $\overline{\times}[t]$

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<th>a tap</th>
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example of covert contrast

• /t/, /k/ → [c] (Gibbon and Crampin 2001)
undifferentiated gestures
research on UGs (Gibbon, 1999)

• 12/17 children had UGs (mean 8;05 years)
• moderate-severe articulation disorders
• slow progress in speech therapy
• no identifiable organic aetiology
• some had label CAS
description of UGs

- increased tongue-palate contact which extends from alveolar into the palatal/velar regions
- also termed “whole tongue” gestures
dynamic EPG patterns for /d/ in the **dolls**

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<tr>
<th>Group</th>
<th>Name</th>
<th>(Age)</th>
<th>EPG</th>
<th>Audio</th>
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<tr>
<td>TD</td>
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<td>(12:00 yrs)</td>
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<tr>
<td>Non_UG</td>
<td>Steven</td>
<td>(10:05 yrs)</td>
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<tr>
<td>UG</td>
<td>Bruce</td>
<td>(13:06 yrs)</td>
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<tr>
<td>UG</td>
<td>Sarah</td>
<td>(8:06 yrs)</td>
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relevance to functional disorders

• indicates motor based speech disorder particularly affecting tongue control
• explains auditorily inconsistent productions of lingual plosives (Gibbon and Wood 2002)
• suggests why these children lack motorically complex sounds and sound sequences
• accounts for their intractable speech disorders and failure to respond to traditional speech therapy
perceptual variability

Target
/d/ in the dolls  /t/ in a toolshed  /k/ in a car

EPG

Audio

Bruce, functional disorder, aged 13;06 years
interpretation of UGs

• reflect impaired speech motor control (Gibbon 1999)
• delayed or deviant motor control of functionally independent regions of the tongue
• failure to develop control for volitional movement patterns during speech
relevance to childhood apraxia of speech

- UGs underlie some key CAS symptoms
- inconsistent productions
- lack of motorically complex sounds and sound sequences
- problems with DDK rates
- failure to respond to speech therapy
EPG as a therapy tool
EPG as a therapy tool

• provides visual feedback of tongue palate contact patterns
• /s/, /z/, /ʃ/, /ʒ/ (lateral/palatal lisps, stopping, glottal/pharyngeal substitutions)
• /t/, /d/, /k/, /ɾ/ (velar fronting, alveolar backing, palatalisation, abnormal double articulations variable placement)
• /l/ (gliding)
• clusters (reduced)
EPG as a therapy tool

- assists in therapy for abnormal compensatory errors (due to abnormal learning) motor-based and phonological speech errors
- most EPG studies focus on changing spatial patterns, not abnormal timing of gestures
- therapy goals based on detailed analysis of EPG patterns pre-therapy
subject selection

- age
- literature on efficacy
- type of speech disorder
- associated factors
- motivation and therapy compliance
- orthodontic considerations and tolerance of palate
- family support
stages of EPG therapy

- demonstrations, explanations and verbal labels
- understanding of the relationship between the upper palate and the shape of the EPG pattern
- awareness of the link between the EPG shape and the sound
- labels to describe EPG patterns
stages of EPG therapy

• practise with and without visual feedback
• silent articulatory gestures
• alternate new movement patterns with established, correct ones
• alternate silent with audible articulations
• use in a variety of vowel environments
• minimal pairs and increase complexity of phonetic contexts
• carry over
portable training unit

- visual feedback only
- lightweight and portable
- inexpensive
- simple to operate
efficacy of EPG therapy

- majority of studies report functional disorders and cleft palate
- single case studies all report positive change (Gibbon and Hardcastle 1987; Gibbon et al. 1990; Gibbon et al. 1993; Gibbon et al. 1999; Gibbon and Wood 2003)
- small groups of 2/3 report positive change in some but not all cases (Dagenais et al. 1994)
- study of 12 children with cleft palate: dramatic improvement in 33%; moderate improvement in 33%; minimal improvement in 33% (Gibbon et al. 2001)
Rebecca (female, 12;3 years, Dent et al. 1995)

• functional articulation disorder (lateral lisp)
• a saw

before therapy

after therapy
Emma (female, 9 years, Gibbon et al. 1993)

- functional articulation disorder (alveolar backing)
- a tar

before therapy

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after therapy

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David (male, 9, Gibbon and Wood, 2003)

- functional articulation disorder (velar fronting)
- a cap

before therapy  after therapy

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CLEFTNET

- CLEFTNET
- to provide an EPG therapy service for people with cleft palate living in Scotland, England, Wales and N Ireland
background

- set up in 1996 by QMUC in collaboration with SLTs working with cleft palate in Scotland
- the only facility to provide a nation-wide EPG therapy service
how CLEFTNET works

• cleft palate centres in Scotland have EPG systems and PTUs
• an electronic network links the cleft palate centres with QMUC
• this allows the centres to transfer data immediately to QMUC
data gathered

• brief medical, developmental and speech and language therapy history
• CAPS
• EPG data (CAPS sentences + an additional word list)
• minimum of two recordings made, before and after EPG therapy
CLEFTNET database

- allows researchers to study a relatively large group of speakers
- 30 speakers with cleft palate in the database
- basis for 6 publications in international journals, plus 3 final year students’ honours projects
CLEFTNET UK
Start date: November 2004
CLEFTNET UK

- a bigger and more ambitious project than CLEFTNET Scotland
- involve all regional centres in England, Wales and Northern Ireland
- operate in a similar way to the original project
- provide a UK-wide EPG therapy service for people with cleft palate
- a unique and substantial articulatory database
EPG requirements per centre

- each centre buys its own equipment
- EPG (1 system)
- PTUs (6-12 units)
- commitment to fund EPG palates (18-24 per year)
role of QMUC

• to employ an IT specialist and an RA
• to run workshops and provide technical and specialist EPG support
• to process EPG data sent electronically from the centres
• to advise SLTs on strategies for EPG therapy
• to manage the database
role of collaborators

- to learn how to use EPG in diagnosis and therapy
- to select clients
- to make recordings and transfer data electronically to QMUC
- to liaise with SLTs working at other centres
- to provide EPG therapy for selected children
- to be involved in research