GENERAL OUTLINE OF THE COURSE

1. MODELS OF NORMAL SPEECH PRODUCTION & CLASSIFICATION OF DYSARTHRIAS (DAY 1)

2. PERCEPTUAL EVALUATION OF SPEECH INTELLIGIBILITY IN DYSARTHRIA (DAY 2)

3. ACOUSTICS OF SPEECH INTELLIGIBILITY IN DYSARTHRIA & PUTTING IT ALL TOGETHER (DAY 3)

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PART 1
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ACOUSTICS OF SPEECH INTELLIGIBILITY IN DYSARTHRIA
OUTCOME

STUDENTS HAVE KNOWLEDGE OF

1. THE GENERAL STRUCTURE OF MODELS OF NORMAL SPEECH PRODUCTION AND SPEECH MOTOR CONTROL

2. TESTS USING PRAAT'S MFC FACILITY

3. A SELECTED SET OF ACOUSTIC CORRELATES OF SPEECH INTELLIGIBILITY IN DYSARTHRIAN SPEECH

4. HOW TO ANALYZE AN ACOUSTIC SAMPLE USING A FEW BASIC ACOUSTIC PARAMETERS

5. HOW TO PERFORM STATISTICAL ANALYSES THAT RELATE PERCEPTUAL AND ACOUSTIC DATA (E.G., REGRESSION ANALYSIS, T-TESTS ETC.)

LITERATURE AND COURSEWORK

Recommended reading:

SPEECH PRODUCTION MODELS:

ACOUSTIC STUDIES OF SPEECH MOTOR DISORDERS:


ACOUSTIC CORRELATES OF SPEECH INTELLIGIBILITY:

GENERAL READING ON SPEECH PHYSIOLOGY AND NEUROLOGY:


Coursework:
Write a short (3-4 page) report on the acoustic and perceptual analyses of the speech sample used in the workshop. Discuss the results in terms of current literature on the acoustic and perceptual correlates of speech production deficits in dysarthria.
DISORDERS OF SPEECH MOTOR CONTROL

DEFINITIONS:

Dysarthrias are speech disorders that result from neurologic impairments associated with weakness, slowness, or incoordination of the musculature to produce speech (Duffy, 1995).

Apraxia of speech (in adults) is a result of a focal brain damage that impairs especially the processes of planning or programming speech movements in the face of essentially normal strength, speed, and coordination of the speech musculature. Apraxia affects programming of speech movements, dysarthria affects execution of these movements. (N.B. Both have acquired and developmental forms!)

A MODEL OF SPOKEN WORD PRODUCTION

CURRENT STANDARD MODEL:

- What is represented?
  - Interactive models
  - Each other
- Levels are independent from each other.
- To what extent processing

MAJOR ISSUES:

FORM ENCODING (3 stages)

LEXICAL SELECTION (2 stages)

A serial two system model:

e.g., Levelt, W. et al. 2001

Kent (2000)

Consonar (2006)

Levelt et al. (2001)

KEY READINGS:

LEVELT, W. et al. 2001

Guenther (2006)

Kent (2000)

A slight oversimplification: Apraxia affects programming of the speech musculature (Duffy, 1995).

Apraxia of speech (in adults) is a result of a focal brain damage that impairs especially the processes of forming speech (Duffy, 1995).

Dysarthrias are speech disorders that result from...
A MODEL OF SPOKEN WORD PRODUCTION

Phonetic encoding can be broken down by competitive queuing of subcomponents. More likely, parallel activation of subcomponents can be handled by competitive queuing of subcomponents. Serial order cannot be implemented using associational serial order in a processing system with multiple subcomponents and a serial output system.

PROBLEMS

MODELING SPEECH PRODUCTION

Phonetic encoding and articulation. Problems in speech motor control are related to the disorders in the phonetic encoding and articulation system. "Subordinating of subprograms, and execution of the plans (by the phonetic plans) (the motor programs), retrieval of the plans, and articulation can be broken down to the formation of the articulatory score."
Syllable effect refers to experimental finding which shows that it takes somewhat longer. Word (≈3.3 words/sec) Syllable (≈3.8 syll/sec) Phone (≈10 sounds/sec) Speed of information transfer:

What is the basic unit of speech production?
DIVA MODEL

A SELECTIVE ACCOUNT OF DIVA & NEURAL STUFF (e.g. Guenther, 2006)

- Development: How does it all start?
- Auditory-motor interaction: What is the role of auditory feedback?
- Reference frame for productions:
  - Auditory goals: What is the role of auditory feedback?
  - Interactions: How does it all start?

CORTICAL AND SUBCORtical CORRELATES OF SPEECH MOTOR CONTROL
COMPONENTS OF THE DIVA MODEL

1. Inverse kinematics controller
   - Phonemic-to-acoustic-mapping (transforms the phonological sequence to acoustic targets according to the internal model)
   - Internal (learned) model (provides information on the state of the vocal tract)
   - Adder (calculates the difference between the current and the target state)

2. Inverse dynamics controller
   - Articulation-to-muscle mapping (computes muscle lengths)
   - Adaptive controller (computes the activation patterns of the muscles)

3. Vocal tract model
   - Biomechanical vocal tract model (simulates the movements of the muscles)
   - Acoustic (or articulatory) synthesis (transforms the phonological sequence to acoustic targets according to the internal model)

EXAMPLE: Production of /r/

Lot of variation across individuals in articulatory patterns (F3 transitions are relatively stable), acoustic patterns (F3 transition) are relatively stable.
Acoustic target region is relatively stable. Articulatory targets vary as a function of context.

**Articulatory trade-off (tongue height vs. lip rounding)**

Motor equivalence can have saturation effect of articulatory commands. Saturation effect of motor commands can have variation (slack) biomechanical restrictions.

**Example:** /ugi/
Circle of Willis

Blood Circulation of the Brain:

Major arteries to the brain:

A Bit of Neurology
A BIT OF NEUROLOGY

BLOOD CIRCULATION OF THE BRAIN:

CIRCULATION AREA OF ANTERIOR CEREBRAL ARTERY, VIEWED ON MEDIAL ASPECT OF RIGHT HEMISPHERE

CIRCULATION AREA OF MIDDLE CEREBRAL ARTERY, VIEWED ON LATERAL ASPECT OF LEFT HEMISPHERE

CIRCULATION AREA OF POSTERIOR CEREBRAL ARTERY, VIEWED ON MEDIAL ASPECT OF RIGHT HEMISPHERE

UPPER AND LOWER MOTOR NEURON (two nuclei)

CELL BODY OF NEURON IN THE MOTOR GROUP OF CEREBRAL NERVE
A BIT OF NEUROLOGY

SENSORY PATHWAY

Brainstem nuclei involved in speech

Three nuclei

(Three nuclei)
CLASSIFICATION OF DYSARTHRIAS

Darley, Aronson, Brown (1969, 1975); Perceptual and neurological characterization of speech motor disorders

<table>
<thead>
<tr>
<th>Type of Dysarthria</th>
<th>Classes of Deeper Dimensions</th>
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<tbody>
<tr>
<td>Hyperkinetic</td>
<td>Basal ganglia, especially putamen or caudate</td>
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<tr>
<td>Hyperkinetic</td>
<td>Cerebellum of the olivary pathways</td>
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<tr>
<td>Hyperkinetic</td>
<td>Both upper and lower motor neurons</td>
</tr>
<tr>
<td>Hypokinetic</td>
<td>Upper motor neuron (one or more cranial nerves)</td>
</tr>
<tr>
<td>Hypokinetic</td>
<td>Lower motor neuron</td>
</tr>
<tr>
<td>Hypermetric</td>
<td>Spastic—fascicul</td>
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<td>Hypermetric</td>
<td>Fasicul</td>
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<td>Hypometric</td>
<td>Fasicul</td>
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</tbody>
</table>

Table II. Major classes of deep perceptual dimensions for dysarthria, as reported by Darley et al (1969, p. 1969a).
FLACCID DYSARTHRIA

Typical Location of the Lesion:
Lower motor neuron or peripheral nervous system

Typical Neurological Symptoms:
- Atrophy of the muscles innervated by the affected lower motor neuron or peripheral nerves
- Fasciculations
- Reduced reflexes
- Nasality
- Articulation
- Phonation
- Breathing

Speech: Reduced range and speed of lip, tongue

Subcomponent of speech: Articulation of the nucleus of the facial nerve (VII) and the tongue in the medulla (Hypoglossal, XII)

Broader Subcomponent of speech: Articulation of the nucleus of the trigeminal nerve (V) and the masseter, temporalis, etc.
FLACCID DYSARTHRIA

Hypernasality
Voice quality usually rough and stringent
Flat prosody (especially intonation)
Slow speech rate, imprecise consonants

SPEECH:
Biting, sucking etc.
Hypernasality, imprecise articulatory movements
(Due to paralysis of the soft palate or tongue)
Voice disorders (breathy and/or rough quality due to
paralysis of the larynx and/or lips)
Possible respiratory problems:
Leakage of air.

Hypernasality, imprecise articulatory movements

SPASTIC DYSARTHRIA

Typical location of the lesion:
Upper motor neuron
Bilateral lesion produces chronic symptoms
Unilateral lesion: Transient symptoms (most
head muscles are bilaterally innervated)

Typical neurological symptoms:
Spasticity of muscles, reduced speech of
movements, (hyper)sensitive reflexes; in severe
cases primitive reflexes present (involuntary
biting, sucking etc.)

Speech:
Slow speech rate, imprecise consonants
Flat prosody (especially intonation)
Voice quality usually rough and stringent

Conversation:
Alternating movements [ka-la-ja; prolonged /a/]

Hypernasality, imprecise articulatory movements
(Due to paralysis of the soft palate or tongue)

Speech (symptoms depend on the exact location of
the lesion and affected cranial nerves)
Imprecise articulation
Voice disorders (breathy or stringent)
Hypernasality, reduced loudness of the voice

**SPEECH:**
- Reduced facial expression
- Reduced automatism of movements
- Rest tremor
- Akinesia (reduced movements)
- Rigidity (stiffness of muscles)
- On-off phenomenon

**TYPICAL NEUROLOGICAL SYMPTOMS:**

Idiopathic Parkinson's disease, Parkinsonism (drugs, strokes)
Reduced facial expression
Reduced automaticity of movements
Language problems in later stages
Rest tremor
Akinesia (reduced movements)
Rigidity (stiffness of muscles)
On-off phenomenon

**TYPICAL LOCATION OF THE LESION:**

Primarily in the basal ganglia (substantia nigra and locus ceruleus; disorder in the dopamine secretion)

**HYPOKINETIC DYSARTHRIA**

Imprecise articulation
Voice disorders (breathy or stringent)
Hypernasal
Short sentences
Monotonicity
Slow speech rate

**SPEECH:**

**TYPICAL NEUROLOGICAL SYMPTOMS:**

Lower and upper motor symptoms

**TYPICAL LOCATION OF THE LESION:**

Mixed Dysarthria

Injuries
- Injuries (such as ALS or MS), strokes, traumatic brain

Upper or lower motor neuron lesions caused by progressive
HYPERKINETIC DYSARTHRIAS

TYPICAL LOCATION OF THE LESION:
Extrapyramidal system, basal ganglia

TYPICAL NEUROLOGICAL SYMPTOMS (fast form):
Myoclonic jerks (tics)
Chorea
Hemiballism
Spasmodic dysphonia
Problems in voice control
Bursts in articulation
Fast changes in loudness or pitch

SPEECH:

TYPICAL NEUROLOGICAL SYMPTOMS (slow form):
Athetotic and dystonic movements (slow involuntary movements)

SPEECH:

Extrapyramidal system, basal ganglia

HYPERKINETIC DYSARTHRIAS
ATAXIC DYSPHARIA

SPEECH: TWO DIFFERENT FORMS

1. Scanning speech: prosodic problem; every syllable is stressed, syllable durations are lengthened.
2. Coordination problem with articulation: “drunkard speech”; sudden “collapses” of articulation.

Typical neurological symptoms:
- Problems in initiating movements
- Problems in producing rhythmic movements
- Incoordination of movements
- Hypotonicity of muscles
- Intention tremor
- Tumor

Typical location of the lesion:
- Cerebellum and/or connecting structures