Gotland workshop: Summary of session "Analysis of vowels"

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Summary of the session on "Analysis of vowels" at the Gotland workshop, August 16, 1979; Part (a) Data for production models
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Available methodological approaches for studying speech production processes may be summarized as in Table I. Among the models, we shall concentrate on physical models for the present discussion. The three-dimensional tongue model is a typical example, where we specify muscular forces as inputs and compute the tongue shape, the vocal tract area function, and the F-pattern.

As the means for obtaining data about production processes in connection with model construction and interpretation of observed phenomena, we may list a variety of techniques as in Table II. Some examples of such techniques and the classes of topics were discussed: the computer-controlled x-ray microbeam system and the derivation of component gestures of tongue articulations for vowels, a new stereofiberscope with a magnetic bridge for joining the optical cables within the pharynx, a topic of laryngeal conditions, in particular larynx height, in relation to accent patterns and vowel devoicing, an example of electromyographic data of the laryngeal gestures in relation to accentual control where physiologic signals reflects the linguistic control better than acoustic (fundamental frequency) signals, and dynamic palatography (electropalatography).

It was emphasized that speech phenomena are inherently variable both within a speaker and among different speakers, and this makes it necessary to obtain and process a large amount of data. At the same time, none of the available techniques for deriving data at different levels of the hierarchy of speech production levels is complete in supplying us relevant information. Consequently, the best we can do is to combine all sets of fragmentary data obtained at different levels preferably simultaneously, and relate them to each other via models that map one level to another, in the effort to arrive at a good understanding of a comprehensive picture of the dynamic process of speech. It was pointed out that vowels as syllable nuclei play essential roles in determining the inherently dynamic and continuously moving process of speech production, which has to be described as a multidimensional system with complex temporal characteristics.
Comments were contributed concerning electric measurements of the glottal and labial conditions, magnetic and optical measurements of the tongue gestures, CT-scanning measurements of the vocal tract cross-sections, acoustic impedance measurement (its proposal, attempts, technical difficulties and future prospect) for deriving area functions, vocal cord models and their implications.

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Methodologies

1. Physical/Physiological Measurements
   histochemical, mechanical, electric, magnetic, optical, ultrasonic, acoustic, radiographic

2. Statistical Induction
   principal component analysis
   multidimensional analysis (INDSCAL, PARAFAC)

3. Deductive Interpretation
   analysis-by-synthesis
   linear- or nonlinear-multiple regression

4. Model Construction
   physical (computational) models
      - finite element method, etc.
   psychological models
      - motor programming/execution
   phenomenological models
      - target/locus, lookahead, coarticulation

5. Linguistic Theory -- Phonetic Code
   phonemes, distinctive features, syllables
   core-affix, demisyllables, metric structure

6. Control Theory -- Feedback Loops

TABLE I
Measurement Techniques

2. Supralaryngeal
   a) Dynamic Palatography
      (electric; optical distance measurement)
      computer data analysis/acquisition
   b) X-rays
      cinefluorography
      computer-controlled microbeam
      (automatic pellet tracking)
      interactive analyses
      automatic annotation/retrieval
      data base
   c) Others - Physical
      mechanical
      ultrasonic
      magnetic
      optical
      electric
   d) EMG
   e) Others - Physiologic
      EEG
      magnetic (cerebral)
      radiographic (cerebral)

TABLE II