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Phonetics Laboratory
Department of Linguistics
Stockholm University
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This issue of *Perilus* was edited by Mats Dufberg and Björn Lindblom. *Perilus* contains reports on phonetic research at the Department of Linguistics, Stockholm University, Stockholm, Sweden. Copies are available on request.

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New format of Perilus

This issue of Perilus marks a change of goals. Earlier issues have been collections of longer articles resembling those of an international journal. From now on Perilus will take the form of an annual report containing abstracts of articles published elsewhere. Thus the main goal of Perilus will be to publish such annual reports. However, occasionally we shall use Perilus to publish dissertations in phonetics and materials from symposia or conferences organized by our group.

We hope that the reader will find the information (s)he needs in the new format of Perilus.

Björn Lindblom and Mats Dufberg, editors

Contents

Report of 1993/94

A view of the future of phonetics 7
Björn Lindblom

Laboratory group 17

Current projects and grants 19

Publications 1993/94

References 21

Abstracts 27

Previous issues of PERILUS 73

Report of 1993/94

A view of the future of phonetics[1]

Björn Lindblom

Summary
To produce new knowledge and promote applications serving practical needs fundamental research is necessary. However, as hard times strike and research funding is cut, sponsors in government and other sectors tend to demand useful results *without* expensive "digressions" into basic science. Should the future of phonetics be entrusted to applied areas? Will phoneticians succeed in convincing sponsors of the intrinsic and practical merits of their own research? The future of phonetics is in whose hands? Phoneticians still have a choice.

"What is a phonetician?"
At the opening of the XIIth ICPhS at Tallinn, that question was raised by Ladefoged (1988) who noted that "communication engineering, physical acoustics, psychology, anatomy, physiology, linguistics, applied linguistics, computer science and poetry" are part of our lives as phoneticians.

" ... we are phoneticians, we, the people who come to phonetics congresses, and know something about some of these diverse disciplines. None of us can know enough about all of them, *which is why being a complete phonetician is an impossible task*. But every four years we can get together and pool our knowledge. This is phonetics." (Ladefoged 1988; italics ours).

Ladefoged is right in saying that a complete mastery of all the disciplines that overlap with phonetics is an impossible task for any single individual. But is such broad knowledge really a relevant goal? Is it not the case that our interest in adjacent fields is limited to those aspects that help us answer the questions we ask?

1) Slightly modified, this text will also appear in *European studies in phonetics and speech and speech communication*, G. Bloothooft, V. Hazan, D. Huser, and J. Leisterri (eds.), and in the proceedings of the XIIIth International Congress of Phonetic Sciences, Stockholm, Sweden.

Phoneticians seek facts and insights about how speech is produced, perceived and acquired. And about how the world's sound patterns are related to the on-line phenomena of speaking, listening and learning. It seems clear that those and other questions are highly interdisciplinary presupposing bits of knowledge coming from anthropology, biology, cognitive science, computer science and engineering, linguistics, literature and music theory, mathematics, neuroscience, philosophy, physics, sociology and several other fields. The student of sign language is in an analogous sitation.

Is a phonetician a jack of all those trades, but a master of none of them? Or a person with an agenda defined by the questions (s)he asks? Somone who makes *selective* use of information from a variety of sources? Who uses only what helps explain certain facts and makes certain measurements possible?

According to the second possibility, a phonetician is a person seeking an understanding of the issues most relevant to developing phonetic theory and who aims at acquiring *enough knowledge* about other fields to be able to extract relevant information from them and put it to productive use. "Being a complete phonetician" would still be a remote goal and a forbidding task for the individual, but not one that we could not easily cope with, given good questions, good methods and lots of colleagues to argue and interact with.

If we opt for the latter definition, what are the questions? That, of course, is one of the issues to be debated at the ICPhS 95. I would like to offer here a short sketch of my own line of reasoning and the priorities that it gives rise to.

Why phonetics belongs in a biological framework

To structuralists like Saussure, the form of language was a set of social conventions shared by the members of a speech community. During the second half of the 20th century, a significant event was the appearance of Chomsky's *Syntactic Structures* which made explaning why children acquire their mother tongues the ultimate goal of linguistics. Chomsky's writings have undoubtedly been major factors in turning the focus of linguistic theory from the descriptive to the explanatory, from the group to the individual and, thus, from the social to the biological.

Seeing language as a fundamentally biological phenomenon is particularly compelling in the light of language typology and language acquisition. Language is unique to our species. There is no known human culture without language. On the surface, the world's languages vary greatly in terms of their grammar and phonetics, but behind all the geographical, historical and seemingly diverse facts, a great many structural similarities have been identified. Looking at acquisition we note that children learn to speak (or to use sign) spontaneously without conscious effort or explicit instruction. They do so in a period of time which is remarkably

short in view of the complexity of what they acquire and considering the incomplete and often degraded input that reaches their ears (the "poverty of input" argument). Children who grow up in linguistically deprived environments give especially vivid examples of the alleged "information-poor" input and the "spontaneity" of the process. For instance, children surrounded by speakers of "pidgin", lack normal adult models. Nevertheless they develop "creole" languages that are more complex and more similar to normal adult languages. Also, there are reports on deaf children whose hearing parents do not master sign language well. On their own these children apparently acquire a sign grammar that is more elaborate than that of the input and closer to the normal adult model.

Facts such as these inevitably lead to the conclusion that human language could not possibly be something that a few of our ancestors thought of, and which then caught on and spread across the globe. Language is not a "cultural invention". It must be seen rather as a biologically based behavior unique to man.

If biology, what kind of biology?

To many syntacticians and psychologists, language form is complex and arbitrary, and, although all languages appear to be cut from the same cloth, their formal idiosyncracies, so the argument goes, defy functional explanation.

Leading phonologists (Anderson, 1981) concur with this "view from syntax". Briefly stated, their claim about sound patterns is that, when everything associated with language use (production, perception, learning, memory, social factors etc) has been accounted for, there will remain a large core of phenomena, "...'Language per se'...", the innate language faculty, "which is not reducible to features of other kinds.... It is exactly this area ... that ought to occupy the central concern of linguists if they wish to arrive at an adequate conception of the essential and special nature of human Language" (Anderson 1981:495).

While fully accepting that learning language is a biological process, many behavioral scientists have not embraced the notion that language form is beyond functional explanation. Among them are phoneticians like ourselves. Our perspective on sound structure brings out the obvious — but by no means trivial — facts that all phonetic forms must be pronounceable, and that phonetic forms that differ in meaning must meet the condition of perceptual distinctiveness. Less obvious, but nevertheless true, is the fact that as these conditions, pronounceablitity and distinctiveness, interact during the development of a lexical system, they are capable of giving rise to structures of considerable complexity in completely unsupervised, self-organized ways.

The 'formalist' and the 'functionalist' views contrasted here both attribute a strong biological component to language learning. Both views share the assump-

tion that language acquisition results from an interaction between two components: innate "predispositions" on the one hand, and experience of the ambient language, on the other. What exactly is the nature of these two components? This is where the two approaches differ in two major ways: They disagree on how the linguistic facts should be interpreted (the *arbitrary* vs *natural* issue), and on the nature of the innate "predispositions" (the *modular* vs *non-modular* issue, that is "specific to language", or "not specific to language").

To the formalist, languages are underlyingly similar but built in arbitrary and basically unnatural ways. The reason children learn language, despite its formal idiosyncracies, is that they are equipped with a 'language organ', a specialized "module" in their brains. In Chomskyan terminology: Universal Grammar, a prespecification of possible grammars from which children select their native languages by 'parameter setting'.

To the functionalist, on the other hand, language form, especially phonology, is natural, and hence normal children learn it effortlessly. As shown by a huge literature on speech development and child phonology, children develop sound structure as a result of an interaction between the linguistic input and "innate behavioral predispositions".

What is the difference, then, between the two approaches? Are Universal Grammar and "innate behavioral predispositions" two different names for the same thing? The answer is provided by how the two approaches take their stance on the naturalness and the modularity issues.

While the formalist says no to naturalness and yes to modularity, the functionalist's responses are the opposite. The functionalist assumes that, on the path to the adult phonological system, the child gets significant help from what she finds pronounceable (neuro-motoric constraints on the production of speech), what appears salient and distinctive in the speech stimulus (auditory and perceptual constraints). Clearly, the mechanisms of hearing and the respiratory, phonatory and articulatory apparatus, are products of man's "innate endowment". But, importantly for functionalist methodology, those mechanisms are not "modular" (specific to language), since they subserve a number of other functions as well (listening to non-speech, breathing, processing food etc). (The analogous argument applies to the production and perception of sign). It is precisely at this point that the "view from syntax" diverges drastically from the "view from phonetics".

Accordingly, the functionalist hypothesis says that, by making natural movements and sounds that are adapted to production constraints, the child "fortuitously" stumbles over aspects of the adult phonology from which further, more differentiated development can then occur.

An illustration: At about six months of age children begin to produce "canonical babbling": [bababa], [dadada] etc. A simplified, but instructive account of this behavior might be given as follows. (It might be termed the *easy-way-sounds-OK* approach, or, in Swedish, *görs-lätt-hörs-rätt modellen*). The child who hears others communicate tries to participate by making articulatory gestures that are as motorically "natural" (=biomechanically low-cost) and as acoustically "salient" as possible.

Result: A vocalization with articulators in near-neutral positions combined with a mandibular open–close oscillatory movement. By doing this, the child ends up with an utterance that is not yet language, but which resembles it very strongly: [bababa], [dadada] etc. The syllable-like aspects of canonical babbling are "emergents", that is novel features arising as fortuitous consequences of a search strategy set up to scan the space of motoric possibilities from low to greater production "complexity" (Willerman, 1994).

The point is that, in this case, children appear to get significant help, not from prespecified, "specific-to-language" information in Universal Grammar, but from general behavioral processes such as "adaptation" and "emergence". According to this interpretation the striking thing about canonical babbling is not that it shows the child coming closer to language, but rather language (phonology) being of a form that is close to the child. From the child's point of view is, in a sense, located "just around the corner".

Restating and generalizing: Is *language as a whole* learnable because it is eminently natural and reachable via processes of "adaptation" and "emergence"? Or is adult linguistic competence so hopelessly remote from where the child starts that it needs help from "specific-to-language" specializations in our genetic endowment (cf Universal Grammar)? Broadening the perspective further: To what extent should the contents of the phonetic systems that are found in the world's languages, and that are acquired by the world's children, be seen as "formal, largely prespecified, idiosyncracies". Alternatively, to what extent should they be seen as natural, behaviorally derived "adaptive emergents"?

The case for Universal Grammar rests largely on arguments from syntax. More familiar with speech processes and sound structures, phoneticians view things differently: Presumably, most of us believe that it is no accident that, in the world's languages, we find close matches between the facts of sound structure on the one hand and the phenomena of on-line speech on the other. A parsimonious (and an, in principle, uncontroversial) interpretation of such observations would be that phonological units and processes are adapted to their use in speaking, listening and learning. Implication: *Why should syntax be different*?

Why phonetics has a privileged role

Phonetics is in a particularly good position for applying the program of contemporary biology to language. If it does, prospects are favorable for arriving at a more complete and profound explanatory theory not only of speech, but eventually of human language as a whole. Phonetics could lead the way in such an undertaking, because phoneticians have more direct access to the stuff that explanations are made of, namely facts and principles whose empirical motivation is independent of the data to be explained. Phonetics can invoke knowledge which is relevant to speech but which was acquired independently of it, often in adjacent fields, such as information on the general mechanisms of hearing and motor control, a circumstance that gives phonetics a situation that is unique compared with that of other domains of linguistic inquiry (cf syntax), and perhaps also that of many areas of biology. From that perspective being a jack of all trades turns out to be an asset, not a handicap.

The influence of "market forces" on research priorities

In his opening plenary address of this congress, Kohler asks: Is phonetics a language science in its own right? Indeed it is, he concludes, by virtue of the paradigm of phonetic phonology and phonetic explanation (Kohler, 1995). The present remarks are compatible with his views. In fact, they go further in suggesting that phonetics may even hold the key to tomorrow's linguistics.

Both Kohler's discussion and our own have a strong programmatic touch. They are as it were *in-principle scenarios* for phonetics. How viable would those (and other possible) scenarios be when confronted with the real world?

We, the people who get together at phonetics congresses, ask the questions that define our field! That may indeed be so, but what determines the questions we ask? Purely intellectual, intra-disciplinary reasons? In principle, *yes*, but, in practice, *only to some extent*. We are all shaped by the niches where we find it possible to survive academically and otherwise. Hence, even the most idealistic thinkers among us must continually adapt to a broad range of academic, economic, sociological and political factors. Internationally for many phoneticians, survival today means work oriented towards practical needs. On teachers of phonetics, there is increasing pressure to adapt curricula to the current needs of the students who are more likely to become active in applied areas than in fundamental research — that is, of course, if they get jobs at all.

So while we are free *in principle* to ask whatever questions we want and to give phonetics the directions that we ourselves favor, we are reminded that, *in practice*, it is ultimately society at all levels that significantly influences how we ask our questions. The contents of our subject matter is shaped by local and global "market

forces'' whether we like it or not. If there is no demand for fundamental knowledge, it is unlikely to emerge, or, if it does emerge despite all odds, it will do so much more slowly.

What is wrong with that? Why not entrust the future of phonetics to applied areas and let our fundamental understanding of speech processes develop as a spin-off from various applications, reaching us, as it were like crumbs from the rich man's table?

Our answer must be no. The following three objections should be borne in mind.

First, working in applied areas we are under absolutely no obligation to promote basic science, to solve problems so that we learn more about human speech. There is no such constraint as ''basic knowledge and theoretically solid science first, then practical applications''. The only objective in applications is that of solving limited and well-defined practical problems in a manner satisfying all performance criteria.

Consider an example from speech technology. Finding out how speech is produced, structured acoustically and perceived is relevant both to the phonetician and the speech technologist. However, phoneticians study human behavior, whereas speech technologists construct machines. Are these tasks basically the same? Yes and no.

Suppose we were to study birds and airplanes rather than humans and speaking machines. Obviously jumbo jets do not flap their wings. Consequently, birds and planes are built according to entirely different performance criteria. There is a parallel here with human and machine speech production. If human ears cannot tell the difference between synthetic and natural speech, but the resulting signals are made in totally different ways, should we refuse to have a certain telephone service installed that sounds all right, but happens to use speech produced by totally ad hoc and non-biological rules? Clearly that would be like waiting to fly until jumbo jets begin to flap their wings. If the telephone service is good enough from the customer's point of view, commercial forces will most certainly impose it on us whether it represents a good model of human speech or not.

Despite the possibility of potentially fruitful interactions with technology and other areas, the overall conclusion is clear: In applied phonetics, we never dig deeper than necessary to solve practical problems. In applied projects the long-term task of explaining speech represents an irrelevant detour. Shortcuts are acceptable and welcome.

Our second objection derives from those conclusions: Using applied phonetics to increase fundamental knowledge offers neither the most direct or fastest route nor any guarantees.

The third and most important objection concerns a fact that is often overlooked in current discussions of research and development. Most technical applications of today were made possible by fundamental research begun a very long time ago.

In that context, our previous metaphorical use of birds and airplanes is somewhat misleading. It gives the justification for the fact that, in applied work, the first priority is solving practical problems, not contributing to basic science.

However, before we accept that conclusion we must stop to consider *how practical problems get solved at all.* The knowledge that goes into a solution must never be taken for granted nor trivialized.

The much more significant implication of the bird–airplane metaphor is therefore this: Although planes are heavier than birds and fly faster, engineers could not have built them successfully without a thorough understanding of *aerodynamics*.

We do not need to be experts on the history of physics to realize that aerodynamics was not invented overnight. Normally, the knowledge that is being put to various practical use today took centuries to accumulate. In our own time, Gunnar Fant and others developed a theory of speech and showed how to apply it to make synthetic speech. Without wanting to detract from the considerable achievements of these pioneers, we should recognize that their efforts were anchored in a thorough understanding of acoustics, a branch of physics with a long history and with a body of knowledge to which Sir Isaac Newton (1642–1727), Jean Baptiste Joseph Fourier (1760–1830), Lord Rayleigh and many others made significant contributions (Hunt, 1992).

The formation of knowledge embodied in scientific theories can be compared to the formation of fossil fuels. They need time to develop. We know that burning fossil fuels leads to a *depletion of resources* and poses a serious growing threat to life on this earth. Many people are therefore hard at work to promote the use of renewable energy sources and advocate a society based on the philosophy of *recycling*.

Analogously, research funding policies that favor applied over basic research represent a kind of ''depletion of resources'' which must be balanced by the long-term support of general and fundamental science. On paper, that would seem to be an obvious responsibility of both state and private organizations. However, as we all know, in practice, maintaining the balance between ''depletion'' and ''renewal'' in scientific research is not achieved automatically. It presupposes a strong and active participation by the researchers themselves.

Concluding remarks

The future strength of phonetics rests on the recognition of two main facts: First, understanding human spoken language is understanding an important part of

ourselves and of our place in nature and society. Pursuing such an undertaking successfully within the framework of general science will result in a rational account of language and speech and will show how man is to some extent unique, but basically a product of the same processes of continuous biological evolution that made all other organisms. The impact of such an account will eventually be enormous as education and communications technology spread it across the globe and to all the cultures of the world. The fact that phonetics has a privileged position in that undertaking makes phonetic research a priority of high timeless and cross-cultural intrinsic value.

Second, technological, educational, clinical and other applications cannot do without a fundamental understanding of human spoken language. Some of our colleagues would no doubt disagree. Numerous proceedings from speech technology conferences convey a strong sense of optimism about the power of computational and statistical methods that should provide shortcuts to the much slower, step-by step and experimentally based search for insights about the way humans process spoken language. The tacit hope seems to be that, before long, we will see systems that achieve speaker independent recognition of connected speech and that do so successfully although they make minimal use of phonetic, linguistic and other behavioral knowledge.

What is probability of success of such efforts? Given the complexity of spoken language, we can safely assume that such systems may score impressively on limited tasks, but are extremely unlikely to ever come near complete success in emulating human performance *unless they are based on comprehensive models of human behavior*. Assuming otherwise would seem to severely underestimate the immensity and complexity of human language. It resembles betting against other events of infinitesimally low probability, e.g. life having arisen several times in several places in the universe.

Favored by sponsors, gambling on shortcuts will no doubt continue to attract people and cost a lot of money, although it appears singularly untempting to the informed phonetician. Supporting, and doing, fundamental research seems like a much safer strategy in making phonetics useful.

Phonetician — a jack of all trades, a master of none? Or a person holding the key to a more profound understanding not only of speech, but of human language as a whole. Phonetics — a science in its own right? Intellectually, yes. There are plenty of good questions around from which to build a future phonetics. But will there be anybody to ask them in the future? For, no matter how forcefully articulated, the long-term priorities of fundamental research continually face the threat of being overruled by short-term definitions of social ''needs'' and of being replaced by the short-sighted agenda of ''immediate usefulness''. However, since

answers to the core questions of phonetics have timeless and cross-cultural intrinsic value and provide the knowledge resources without which future practical applications will not be possible, prospects are good that, armed with good questions, good methods and a critical awareness of the role of external "market forces", phoneticians of the next century will be ready to meet the challenges and will find themselves contributing to one of the most central and dynamic of scientific enterprises: *Understanding human language*.

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Current projects and grants

Articulatory-acoustic correlations in coarticulatory processes: a cross-language investigation

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Project group: Peter Branderud, Olle Engstrand, Bo Kassling, and Robert McAllister.

Speech transforms — an acoustic data base and computational rules for Swedish phonetics and phonology

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Project group: Olle Engstrand, Björn Lindblom, and Rolf Lindgren.

APEX: Experimental and computational studies of speech production

Supported by: The Swedish Council for Research in the Humanities and Social Sciences (HSFR), grant to Björn Lindblom.

Project group: Diana Krull, Björn Lindblom, Johan Sundberg,[1] and Johan Stark.

Paralinguistic variation in speech and its treatment in speech technology

Supported by: The Swedish Council for Research in the Humanities and Social Sciences (HSFR), grant to Hartmut Traunmüller.

Project group: Anders Eriksson and Hartmut Traunmüller.

Typological studies of phonetic systems

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Project group: Olle Engstrand, Diana Krull, Björn Lindblom, and Johan Stark.

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Second language production and comprehension:
Experimental phonetic studies
Supported by: The Swedish Council for Research in the Humanities and Social Sciences (HSFR), grant to Robert McAllister.
Project group: Mats Dufberg and Robert McAllister.

Sociodialectal perception from an immigrant perspective
Supported by: The Swedish Council for Research in the Humanities and Social Sciences (HSFR), grant to Olle Engstrand.
Project group: Una Cunningham-Andersson and Olle Engstrand.

An ontogentic study of infants' perception of speech
Supported by: The Tercentenary Foundation of the Bank of Sweden (RJ), grant to Francisco Lacerda.
Project group: Francisco Lacerda, Björn Lindblom, Ulla Sundberg, and Göran Aurelius.[1]

Early language-specific phonetic development:
Experimental studies of children from 6 to 30 months
Supported by: The Swedish Council for Research in the Humanities and Social Sciences (HSFR), grant to Olle Engstrand.
Project group: Jeanette Blomquist, Olle Engstrand, Bo Kassling, Johan Stark, and Karen Williams.

Speech after glossectomy
Supported by: The Swedish Cancer Society, grant to Olle Engstrand
Project group: Olle Engstrand and Eva Öberg.

Development of technical aids for training and diagnosis
of hearing and speech impaired children
Supported by: Allmänna arvsfonden, grant to Francisco Lacerda.
Project group: Susanne Eismann and Francisco Lacerda.

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Methodological studies of Movetrack — coil tilt and placement[1]

Peter Branderud, Robert McAllister and Bo Kassling

Abstract

This paper concerns the experimental estimation of the accuracy of an electromagnetic transduction system. This system was designed for the observation and measurement of articulatory movements in speech. An overview of measurement accuracy and sources of measurement error is presented which applies to the magnetometry systems currently available. Two systems with so called tilt correction, EMMA and EMA, were compared to the Movetrack system which has no tilt correction. Experiments were carried out to determine procedures which could reduce and control the tilt of the Movetrack's receiver coils on the tongue. Five trained phoneticians produced Swedish vowels and consonants. Tilt angle was measured during static pronunciations and estimated in running speech. It was found that the dynamic and static conditions compare quite closely. It is concluded that, providing the methodological demands discussed in the paper are met, the Movetrack's accuracy and ease of handling make it a useful research tool.

1) Branderud et al. (1994).

Acoustic contrast and the origin of the human vowel space[1]

René Carré[2], Björn Lindblom and Peter MacNeilage[3]

Abstract

The morphology of the human vocal tract (VT) differs from that of other primates. It has been pointed out that, with their high larynges, long mouths and short throats, apes cannot form the pharynx cavity essential to the production of the full range of human speech sounds. Here we describe an algorithm that derives the human "vowel triangle" — both articulatorily and acoustically — given an arbitrary, but normalized, VT shape as input and a criterion of maximal "acoustic contrast" to guide its recursive selection of new sounds and articulations. The results are compatible with the idea that the phylogenetic reshaping of the VT was, in part, phonetically motivated. However, if that view is correct, the present findings also strongly imply that it must have been the "distinctiveness" of the new sounds, rather than their "stability", that gave them their selective advantage.

1) Carré et al., 1994.
2) Département Signal, ENST, Paris, France.
3) Department of Linguistics, University of Texas, Austin Texas 78712, USA.

Socially conditioned variation of /ɧ/[1]

Una Cunningham-Andersson

Abstract

In addition to testing the primary hypotheses of the project "Non-native socio-dialectal perception", we want to study socially conditioned phonetic variation in the Uppsala accent in considerable detail. Candidates for socially conditioned phonetic variables in Uppsala are, for example, the flapped l, intonation, /d/ in pronouns becomes /r/ , the place of maximum constriction of /ɧ/ and a general weakening or strengthening of accent features. This paper is concerned with variation in /ɧ/ in Uppsala. A significant (0.05 level) but fairly weak correlation was found between the socio-educational score of the speaker and both the frequency of the /ɧ/ (as measured using LPC-analysis) and the average range in frequency over the three measurement points for each /ɧ/. This indicates that speakers with higher socio-educational levels (low scores) use, on average, higher frequency /ɧ/:s than do speakers with lower socio-educational levels, and also that the speakers on higher socio-educational levels tend to have more formant movement in their /ɧ/:s than speakers from lower socio educational positions.

1) Cunningham-Andersson, U., 1993a.

Stigmatized pronunciations in non-native speech[1]

Una Cunningham-Andersson

Abstract

This paper reports the results of two experiments exploring the relationship between native Swedish speakers' perception of, on the one hand, different immigrant groups and, on the other hand, different phonetic features of immigrant Swedish. The first experiment showed that speakers can be judged differently as regards how friendly and educated they sound when they use some non-native pronunciations than others. This was interpreted as evidence that attitudes to non-native pronunciations are separate from attitudes to speaker groups. Evidence was also found that a single non-native pronunciation in the same phonetic material produced by different speakers will be judged differently. This shows that the particular non-native pronunciation being used is not the only factor which influenced the listeners in their judgement of the stimuli. Other candidates are speaker characteristics, such as the perceived personality, accentedness, voice quality and sex of the speaker, as well as the assumed ethnic origin of the speaker. One of the naive listener groups (with lower socio-economic and educational status) was found to be significantly influenced in their judgements of the speakers by their beliefs about the speakers' backgrounds. The second experiment resulted in lists of the 94 non-native pronunciations occurring in an extended material in the order of the median judgements they elicited from 91 new listeners on the three judgement dimensions of importance of the non-native pronunciation, speaker friendliness and speaker education. These lists should be of interest to teachers of Swedish as a second language.

1) Cunningham-Andersson, U., 1993b.

Data collection for a sociodialectal study[1]

Una Cunningham-Andersson and Olle Engstrand

Abstract

In this paper, methods used to collect speech data from native speakers of six regional accents of Swedish and one accent of American English are described. This speech data is to be used as stimulus material in a series of listening tests. The criteria used for speaker and listener selection are discussed, and a preliminary listening test is reported. A useful technique for eliciting spontaneous speech from linguistically naive informants is presented where speakers were recorded in pairs of the same race, social group and sex. This tactic proved to be very effective in eliciting natural running speech. The informants were not constrained by the presence of an unknown interviewer, and peer pressure from their partner prevented them from modifying their speech unnaturally. The next part of the recording session took the form of an interview with both of the speakers, during the course of which the speakers' linguistic and social background was documented. This represents a more formal speech style than the first situation, where the speakers were talking to people they knew. This change in situations might be expected to be accompanied by a code switch in bidialectal speakers. The final, most formal, situation in the recordings was the reading of a text.

1) Cunningham-Andersson, U. and Engstrand, O, 1994.

On explaining certain male-female differences in the phonetic realization of vowel categories[1]

Randy Diehl[2], Björn Lindblom, Kathryn Hoemeke[2] and Richard Fahey[2]

Abstract

The scaling between female and male formant frequencies tends to be highly non-uniform across vowel categories with the result that female vowels exhibit greater between-category dispersion than male vowels. Modeling studies strongly suggest that this greater dispersion of female vowels is partly behavioral, rather than purely anatomical in origin. The present study tested one explanantion for this behavioral difference between females and males, viz, that, without the compensatory effect of greater dispersion, the typically higher fundamental frequency (F0) of female talkers would yield reduced identifiability of vowels because of sparser harmonic sampling of spectral envelopes. The specific question addressed was whether, all else equal, a higher F0 has the assumed deleterious effect on vowel identifiability. In two experiments, the overall effect of increasing F0 beyond 150 Hz was to reduce vowel labeling accuracy. Across individual vowel categories, the effect of raising F0 varied. This appears to be attributable, in part, to differing degrees to which a high F0 obscured the distinctive auditory properties of each vowel cateory. Consistent with the spectral undersampling account, the performance decline at high F0:s was reduced or eliminated when F0 was time-varying rather than constant.

1) Diel et al., in press.

2) Department of Psychology, University of Texas, Austin Texas 78712, USA.

Test battery for the measurement of second language perception[1]

Mats Dufberg and Robert McAllister

Abstract

In a project supported by HSFR we have attempted to measure L2 learners' explicit speech comprehension (in the target language) and to correlate that to certain background factors and self assessment. Their speech comprehension is measured explicitly by means of speech comprehension tests. In the article we briefly describe the tests used in the present experiments. McAllister and Dufberg[2] report some preliminary results from the ongoing study. The tests used in the project can be divided into six types:

- Background questionnaire and interview
- Audiometric screening
- Psychoacoustic tests (3 tests)
- Level-based speech perception tests (2 tests)
- Global speech perception test
- Self assessment speech perception test

Our aim has been to use tests with high degree of validity. Since we will attempt to correlate the L2 learners' speech comprehension with their production and with certain background factors, it is fundamental that the comprehension tests do measure what we want them to test. In a previous article[3] we present the model of speech comprehension on which we have based our work. With this set of tests we have tried to satisfy both the validity requirement and the necessity to have manageable tests.

1) Dufberg and McAllister, 1994.
2) McAllister and Dufberg, 1994. Abstract also in this volume.
3) McAllister and Dufberg, 1989, "Some attempts to measure speech comprehension", *Perilus* **6**, 29–52.

Acoustics and perception of Estonian vowel types[1]

Arvo Eek and Einar Meister[2]

Abstract

The purpose of the present study has been to collect reference material on formant frequencies of Estonian vowels in the four-formant production space and to examine perceptually a two-formant approximation to four-formant reference vowels using both matching and identification procedures. Perceptual quantifications of formant patterns are discussed with reference to the spectral integration in envelope reconstruction and to the hyperspace effect in vowel perception. We envisage a framework for the description of the Estonian vowel system on the basis of perceptual distinctive features (with special attention to the vowel /õ/).

1) Eek and Meister, 1994.
2) Laboratory of Phonetics and Speech Technology, Institute of Cybernetics, Tallinn, Estonia.

Investigation of relation between speech and hearing deficiencies in dysphonological children[1]

Susanne Eismann, Francisco Lacerda, Fritjof Norrelgen[2] and Maria Öberg[2]

Abstract

We present a pilot study with the goal to investigate if the speech discrimination of dysphonological children differs from children with normal speech development. The study was performed with nine dysphonological children between 4-5 years of age and a control group of children with normal speech development at the same age. The dysphonological children showed reduction of consonant clusters and they were all examined and remitted by a speech therapist.

In the discrimination test we used a specially developed computer program that reinforces interest by means of visual feedback. The speech stimuli used were digitized natural CCV and CCCV combinations read by a trained female speaker.

The children listened to stimuli pairs in random order over headphones, and were asked to mark the pair members as "same" or "different", using push buttons. At each correct response a graphical object appeared on the screen. Different objects were added, thus creating a complex picture, the complexity depending on the amount of correct responses. The program registered the presentation order of the stimuli, the child's response and reaction time.

The results indicates that the method may reveal certain types of dysphonological problems. For certain phonologically processes the dysphonological children were more erroneous ($p<0.05$) and also showed longer reaction times than the children with normal speech development. (In Swedish.)

1) In Swedish, "Undersökning av samband mellan tal- och hörselsvårigheter hos dysfonologiska barn", Eismann et al., 1993a.

2) Dept. of Logopedics and Phoniatrics, Karolinska Institutet, Stockolm, Sweden.

Computer assisted audio-visual technique for assessment and training of hearing impaired young children[1]

Susanne Eismann, Maria Öberg,[2] Fritjof Norrelgen,[2] and Francisco Lacerda

Abstract

This paper reports an audio-visual method for assessing young (about 4 years old) children's discrimination of speech sounds. The method is implemented as a computer program that automatically presents acoustic stimuli, collects the subject's responses and provides visual feedback.

The aim was to investigate whether the productional difficulties experienced by dysphonological children could be accounted for in terms of auditory deficits.

The subjects involved in the pilot study in progress consists of one group of previously diagnosed dysphonological children and a control group with no known history of speech or hearing impairments.

A test session is divided in a training phase and a test phase. In the training phase the child listens to pairs of non-speech sounds and has to answer "identical" or "not identical by pressing one of two buttons. The training phase proceeds until the child achieves a criterion of 7 correct responses out of 8 consecutive trials. The children who meet the criterion are further tested with the main test. During the test phase the stimuli pairs consist of naturally produced phoneme sequences including sequences for which the dysphonological children are known to have production problems. Whenever the subject provides a correct response a picture element is added to the screen. The complexity of the scene increases constantly with the number of correct responses. The answers and their corresponding reaction times are automatically saved for subsequent statistical analysis.

The investigation is still ongoing and further results will be reported.

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1) Eismann et al., 1993b.

2) Dept. of Logopedics and Phoniatrics, Karolinska Institutet, Stockolm.

Quality judgements by users of text-to-speech synthesis as a handicap aid[1]

Olle Engstrand

Abstract

This paper reports a survey of the need for improved quality in text-to-speech systems for handicapped users. Quality criteria are concerned primarily with those phonetic aspects which affect the intelligibility and naturalness of the artificially simulated speech (rate of utterance, articulatory precision etc.) rather than phonetic expressions of age, sex, emotion etc. (paralinguistic variation). The aim was to a) analyse comments collected from visually and speech-handicapped users, and to a certain extent also from dyslectic users, and b) base the specifications for text-to-speech systems on these analyses. These specifications can then be used when priorities are to be made between future improvements, with the requirements of the users in mind. It was concluded that the following areas should be given priority when seeking to improve the intelligibility and naturalness of the simulated speech: *a) phrasing and pauses, b) stress and focus, c) temporal and stylistic variation*.

1) Engstrand, 1993.

Durational correlates of quantity in Swedish, Finnish and Estonian: cross-language evidence for a theory of adaptive dispersion[1]

Olle Engstrand and Diana Krull

Abstract

Audio recordings of lively conversational speech produced by three Swedish, four Finnish and three Estonian speakers were analyzed for durational correlates of quantity distinctions. The data suggested that duration contrasts are maintained more consistently by Finnish and Estonian than by Swedish speakers. This is attributed to the unusually complex structure of the Finnish and Estonian quantity systems, and to the fact that Finnish and Estonian, in contrast to Swedish, do not use vowel quality or diphthongization as correlates to quantity distinctions.

1) Engstrand and Krull, 1994b.

Aerodynamic measurements of normal voice[1]

Eva Holmberg

Abstract

Vocal fold vibration results from an alternating balance between subglottal air pressure that drives the vocal folds apart and muscular, elastic, and restoring forces that draw them together. The aim of the present thesis is to present quantitative data of normal vocal function using a noninvasive method. Measurements are made on the inverse filtered airflow waveform, of estimated average transglottal pressure and glottal airflow, and of sound pressure for productions of syllable sequences. Statistical results are used to infer mechanisms that underlie differences across (1) normal, loud, and soft voice, (2) normal, high, and low pitch, and (3) between female and male voices. Interspeaker variation in group data and intraspeaker variation across repeated recordings is also investigated. The results showed no significant female-male differences in pressure, suggesting that differences in other measures were not primarily due to differences in the respiratory systems. Most glottal waveforms showed a DC flow offset, suggesting an air leakage through a posterior glottal opening. Results suggested (indirectly) that the males in comparison with the females had significantly higher vocal fold closing velocities (maximum flow declination rate), larger vocal fold oscillations (AC flow), and relatively longer closed portions of the cycle (open quotient) in normal and loud voice. In soft voice, female and male waveforms were more alike. In comparison with normal voice, both females and males produced loud voice with significantly higher values of pressure, vocal fold closing velocity, and AC flow. Soft voice was produced with significantly lower values of these measures and increased DC flow. Correlation analyses indicated that several of the airflow measures were more directly related to vocal intensity than to pitch. Interspeaker variation was large, emphasizing the importance of large subject groups to capture normal variation. Intraspeaker variation across recording sessions was less than 2 standard deviations of the group means. The results should contribute to the understanding of normal voice function, and should be useful as norms in studies of voices disorders as well.

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1) Holmberg, 1993.

Spontaneous adult judgements of infant vowel productions[1]

Tamiko Ichijima and Francisco Lacerda

Abstract

This study is a pilot investigation of how adult listeners spontaneously perceive vowel quality in infant utterances. Recordings of two Japanese infants from the Tokyo area were used to generate the stimuli. One infant was recorded every week between 17 to 24 weeks of age. The other infant was recorded twice, at 32 and 78 weeks of age. The sessions lasted for about one hour and included playing alone, playing with the mother and eating. The stimuli for the perceptual evaluation were a random sample consisting of 57 utterances, drawn from the pool of noise and interference-free utterances. Four phonetically trained subjects judged tongue height and frontness in a speeded judgement test paradigm. The results are compatible with the data from earlier acoustic studies,[2] using careful phonetic transcription. Japanese infants explore the opening dimension during the earlier period of babbling. Although the data cannot be used to establish the exact point at which front/back differentiation emerges, a significant difference was observed between the use of that dimension at 32 and at 78 weeks of age.

1) Ichijima and Lacerda, 1994.
2) Davis and MacNeilage (1990): "Aquisition of correct vowel production: A quantitive case study", *J Speech and Hearing Research* **33**, 16–27.

Word-prosodic features in Estonian conversational speech: some preliminary results[1]

Diana Krull

Abstract

The acoustic correlates of Estonian quantity have until now been investigated in so called "lab speech". The aim of the present study is to describe the acoustic quantity correlates in natural conversational speech.

It can be hypothesized that if an acoustic parameter is used as a primary or single cue to phonological distinctions in a language, then the freedom of the speakers to vary this parameter will be restricted. That is, the parameter should remain robust in any speaking style. This study has two goals: (1) assess the stability of the acoustic quantity correlates; (2) throw some light on the relative importance of different cues of quantity in Estonian.

Estonian has three distinctive quantities: short (Q1), long (Q2) and overlong (Q3). They are signalled by the duration of the segments, and, in particular, by the duration ratio between the first (main stressed) and second syllable of a word. To distinguish between Q2 and Q3, listeners use an additional tonal cue in the first syllable: F0 falls in Q3 and is flat or slighly rising in Q2.

The material of this study consisted of lexical words spoken by a native male speaker of Standard Estonian. Duration and F0 measurements were performed on the two initial syllables of each word.

The results showed statistically significant temporal differences between quantity degrees: the duration of the first syllable increased with quantity degree while the second syllable became shorter, and, as a consequence, the difference in the intersyllabic ratio was particularly pronounced. However, no significant tonal differences were found between quantity degrees.

The results of this study did not contradict the hypothesis at the outset: the temporal quantity cues remained not only stable, but were more pronounced in conversational speech. The tonal quantity correlates, however, were not stable. This suggests that the temporal cues may be crucial for signalling quantity in Estonian.

1) Krull, 1993c.

A study of the physical properties of the movement segment in Swedish sign language — preliminary results[1]

Catharina Kylander

Abstract

First some types of movements in sign language are discussed, then a background is provided as to why the physical properties of the so called transition movement are interesting with regard to the phonological representation.

The movements under consideration are (i) lexical movement and (ii) transition movements within signs. Two types of signs are studied — repeated unidirectional signs and bidirectional signs. The major finding so far is that repeated unidirectional signs are not produced with a straight path movement (as they would be according to the phonological representation) but rather wih a circular movement. (In Swedish.)

1) In Swedish, "En studie av rörelsesegmentets fysikaliska egenskaper i svenskt teckenspråk – preliminära resultat," Kylander, 1993.

Vowel perception during the first year of life[1]

Francisco Lacerda

Abstract
The paper presents basic methodology for infant speech perception research and discusses the implications of some recent results obtained at the Institute of Linguistics, Stockholm University. (In Portuguese.)

1) In Potuguese, "Percepção de vogais durante o primeiro ano de vida", Lacerda, 1993a.

Sonority contrasts dominate young infants' vowel perception[1]

Francisco Lacerda

Abstract

Three groups of normal Swedish infants were tested on their ability to discriminate sonority and chromaticity vowel contrasts, equal in Bark units. The infants were 2–3, 6–7 and 10–11 months old, living in monolingual Swedish environments. The 2–3 month-olds were tested using the High-Amplitude-Sucking technique. The older infants were tested with the Head-Turn procedure. One of the vowel pairs provided an [a]/[ʌ] sonority contrast realized by a 1.8 Bark difference in F1 alone. The other pair was a [a]/[ɑ] chromaticity contrast, in which the vowels differed also by 1.8 Bark but in this case along F2. In spite of the procedural differences, the results show that the three groups of subjects could detect the sonority contrast but that no reliable discrimination could be inferred for the corresponding chromaticity contrast.

1) Lacerda, 1993c.

Infant speech perception[1]

Francisco Lacerda

Abstract

The paper is a summary of a lecture given at the Svenska föreningen för foniatri och logopedi (Swedish Society for Phoniatrics and Logopedics). The paper addresses general aspects of infant speech perception, presents typical research techniques and reviews some recent empirical findings in this research domain.

1) Lacerda, 1994a.

The asymmetric structure of the infant's perceptual vowel space[1]

Francisco Lacerda

Abstract

This paper reports a study of the infant's perceptual sensitivity to F_1 and F_2 changes occurring in the central region of an adult male's vowel space. The data was collected from a group of 16 Swedish infants whose ages varied from 6 to 12 months. The infants were tested with the Head-Turn procedure in their ability to discriminate variants of a reference schwa vowel. Four variants were generated by introducing a fixed increment or decrement (in Bark) along either F_1 or F_2. The results are compatible with previously reported data obtained for vowel contrasts in the low/back region of the vowel space.[2] Thus, the general notion that there is a perceptual asymmetry favoring F_1 differences during the early stages of vowel perception is supported by the present results.

The paper attempts to argue that the early structure of the infant's vowel space might be influenced by the combined effects of both the perceptual dominance of F_1 contrasts and the infant's larger articulatory precision along the open/close than along the front/back dimension.

1) Lacerda, 1994b.
2) Lacerda, 1993. Abstract also in this volume.

Perception of vowel categories in the first year of life[1]

Francisco Lacerda and Ulla Sundberg

Abstract

This paper reports recent findings on infant speech perception. The results indicate that 3 and 6–12 month olds show a greater sensitivity to vowel contrasts involving manipulations of the vowel's first formant frequency F_1 than to contrasts of the same magnitude (as measured on a tonotopical scale) that involve changes in the second formant frequency, F_2. The infants' preference for contrasts conveyed by F_1 distinctions may be related to the way in which the phonological structure of the infants' vowel space develops. According to our data, which so far focus on low back region of the vowel space, the infants' discrimination is better along the opening degree dimension than along the front/back dimension. This result is interpreted as an indication that certain auditory-based processes may determine the early stages of the infants' phonological development by directing the infants' attention to the most salient acoustic variables.

1) Lacerda and Sundberg, 1993.

A preliminary investigation of how prosodic cues may help young infants to extract words from natural sentences[1]

Francisco Lacerda, Ulla Sundberg and Christin Andersson

Abstract

This paper presents preliminary results of a study assessing 6 month-old infants' capacity to pick up linguistically relevant information presented in complex naturalistic linguistic contexts. The Head-Turn procedure was used to investigate the infants' ability to discriminate target words that are embedded in natural carrier sentences. The sentences were produced as infant-directed or adult-directed speech ("direction") and for each direction of the target word occurred either in emphatic or non-emphatic position ("focus").

A large number of sentences, including all the possible combinations of direction and focus, was first submitted to adult scrutiny in order to select unambiguous carrier sentences in which adequate target words were subsequently edited. Both adults and infants were tested by the Head-Turn procedure, to assess the differences between the infants' and adults' use of the prosodic information.

1) Lacerda et al., 1994.

Role of articulation in speech perception: Clues from production[1]

Björn Lindblom

Abstract

The relative roles played by signal properties and non-signal information in speech perception are first examined. The evidence strongly suggests that phonetic percepts are never knowledge-innocent records of the raw signal. That conclusion is drawn not only about "higher" levels of language processing, but is seen to apply also to the perception of elementary phonetic stimuli. A review of a broad range of facts about production highlights the fact that speech production is adaptively organized. That circumstance suggests that the signal does not encode articulatory or acoustic/auditory invariants, but plays the role of supplementing the multi-modal information already in place in the listener's speech processing system. It is accordingly proposed that phonetic signals are not invariants wrapped in "noise", but are products of listener-dependent adaptations that transform speech patterns in principled and, therefore, interpretable ways. Do listeners form speech percepts by way of intermedatiate articulatory representations? There seem to be strong both theoretical and methodological reasons to doubt that they do.

1) Lindblom, in press.

Is sound change adaptive?[1]

Björn Lindblom, Susan Guion[2], Susan Hura[3], Seung-Jae Moon[4] and Raquel Willerman[5]

Abstract

This paper proposes that, in analogy with other phenomena of both biological and cultural change, sound change be analyzed in terms of a two-step process of variation and selection. Phonetic variations are seen to arise from the ability of speakers to adaptively tune their performance to the various social and communicative needs that they associate with specific speaking situations. During the listener's processing, such variation is a means rather than an end. The focus is normally on *what* is being said (message), rather than on *how* it is said (signal). However, occasionally, the "how" information is also conveyed. It is proposed that it is this incidental "how"-mode of perception that provides one of the beginnings of new pronunciations, and that selection, or rejection, by the speech community occurs as a result of an evaluation that language users implicitly perform with respect to, among other things, social, articulatory, perceptual, lexical-systemic dimensions of the new phonetic patterns. Sound change is taken to be adaptive in the sense that, if forms arise that match the current values of the evaluation criteria better than the old forms, they are more likely to be phonologized.

In many respects, the present account follows the listener-based scenario proposed by Ohala. However, it differs in that misperceptions are de-emphasized as the sole seeds of change, and in that a significant role is played also by the speaker.

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1) Lindblom et al., in press.

2) Department of Linguistics, University of Texas, Austin Texas 78712, USA.
3) Department of Audiology and Speech Sciences, 1353 Heavilon Hall, Purdue University, West Lafayette IN 47907-1353, USA
4) Department of English, College of Liberal Arts, AJOU University, Suwon 442–749, Korea.
5) Department of Speech and Hearing Sciences, University of Washington, Seattle, Washington 98915, USA.

Perceptual and statistical classification of vowels[1]

Rolf Lindgren and Susanne Eismann

Contrary to reference speech the vowels from spontaneous speech show large variations and overlap with each other to a great extent. How, then, can we identify a signal as a specific vowel when the signal properties alone give no unambiguous clues? Our approach to investigating this is to combine different acoustic analysis techniques with different statistical classification methods and correlate the results with presumed vowel identity. In a serie of experiments, two artificial neural network paradigms, feed-forward back-propagation (BP) and Kohonen Feature Map (KFM), were used to classify formant patterns of long vowels from reference and spontaneous speech.

Generally, the BP nets have been shown to have a large classification capacity, usually in the range of 90-95%. This also holds for BP trained and tested with reference speech data (97.4%). However, it performed poorly on vowel data from spontaneous speech (36.7%). Also, BP trained on data from spontaneous speech showed a rather bad performance (57.5%). The same pattern as with BP can be seen with KFM when trained on reference speech which yields poor results on data from spontaneous speech (14.8%). In fact, in this case there is a substantial proportion of the data from spontaneous speech that is non-classified (73%). KFM trained on spontaneous speech behaves approximately as BP (40.5% correct), although the overall error rate is slightly larger (57.6% misclassifications).

To evaluate how well "intended" vowel quality (i.e. phonological class) is preserved in spontaneous speech, a vowel identification test was performed, using natural vowels and synthetic vowels, modelled after spontaneous speech. In the perception test with natural vowels, the stimuli were a representantive sample for the total variation of each vowel class taken from the spontaneous speech of one speaker. The synthetic stimuli were synthetic versions of the natural vowels.

The test showed that 52.1% of the natural vowels were perceived in agreement with the labeled vowel quality and in the synthetic version 35.9%. A comparison between the dispersion of the responses for natural and synthetic stimuli reveals that listeners tend to judge the the synthetic vowels according to their location in the formant space, whereas natural vowels to a greater extent carry their intended phonetic quality as they *move* in space.

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1) Lindgren and Eismann, 1994.

Speech motor control[1]

Anders Löfqvist[2] and Björn Lindblom

Abstract

Significant progress in understanding the coordination and control of speech movements has been made as a result of two different but essentially complementary research approaches. First, improved measurement techniques (e.g. electromagnetic transduction) have appeared that have provided new valuable information on articulatory processes. Second, investigators have been able to build computational models that exhibit much greater physiological and physical sophistication than earlier frameworks. These tools have been used to shed new light on how the vocal folds vibrate and how patterns of muscular activity influence articulatory parameters such as the rotation and translation of the mandible and the position and shape of the tongue. Connectionist modeling has been successfully applied to present a unified theoretical account of a wide range of experimental facts about the rate- and context-dependence of speech movements.

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1) Löfqvist and Lindblom, 1994.

2) Haskins Laboratories, 270 Crown Street, New Haven, CT 06511-6695, USA.

A dynamic model for the temporal properties of Swedish[1]

Bertil Lyberg and Barbro Ekholm[2]

Abstract

Segment duration varies depending on a number of linguistic and nonlinguistic factors. At the word and phrase levels segment duration is found to depend on the position in the word and in the phrase. The positional effects on segment duration have been studied by several investigators and, for some languages, models have been hypothesized to describe segmental duration in different positions in words and phrases. The greatest positional effect is the phenomenon of final lengthening that appears to be of considerable generality as a phonetic phenomenon. However, most computational models are static i.e. the durational properties are modelled at a certain speech rate. In this investigation segment duration is studied at different speech rates by means of both reiterant speech and ordinary read speech, and with focus assignment systematically varied along the sentence. A tentative dynamic model for segment duration is presented.

1) Lyberg and Ekholm, 1993.
2) Telia Research AB, Haninge.

The final lengthening phenomenon in Swedish — a consequence of default sentence accent?[1]

Bertil Lyberg and Barbro Ekholm[2]

Abstract

At the word and phrase levels segment duration is known to depend on the position in the word and in the phrase. Of considerable generality is final lengthening which induces a substantial positional effect on duration. In this investigation segment duration is studied at different speech rates and with focus assignment systematically varied along the sentences. The subjects mimicked the prosodic pattern of the utterances by using reiterant speech. From the different utterances an "out-of-focus-utterance" was constructed for each type of sentence by taking out the nonsense words not being in focus position. In most of these "out-of-focus" utterances there was only a slight tendency to a final lengthening effect and in some utterances there was no final lengthening at all. This finding is contradictory to earlier obtained results for Swedish.

1) Lyberg och Ekholm, 1994.
2) Telia Research AB, Haninge.

Studies of perceptual foreign accent[1]

Robert McAllister

Abstract

This paper is a report on ongoing research which focuses on various aspects of the acquisition of second language (L2) comprehension. Specifically, it addresses L2 users' global ability to understand an L2 and compares this communicative ability to that of native speakers. Our point of departure is that the reduced phonetic/phonological capacity of an L2 learner is reflected not only by deviant production, but also by perceptual difficulties or as "perceptual foreign accent" which are at least as problematic in everyday communication situations. Several comprehension test were administered to native speakers and L2 users and test results were compared. Results of this comparison indicate that with increasing perturbation comprehension ability of the L2 users deteriorates at a much faster rate than the native users. Perceptual foreighn accent may then be important to consider in the competence of L2 users and it may be due to L2 users difficulty in processing signal independent information.

1) McAllister, 1993.

Speech communication[1]

Robert McAllister

Abstract

This book is an exposition of the central areas of the subject of phonetics. It includes a summary of structures and mechanisms involved in the production and perception of speech. It also includes a section on acoustic phonetics and a section on the basic principles of phonology and their relation to phonetics. Designed as a textbook primarily for university students of basic linguistics it should also be relevant for several professional areas that have to do with speech, hearing and language such as speech pathology, audiology, and foreign language teaching. (In Swedish.)

1) In Swedish, *Talkommunikation*, McAllister, 1994.

Aspects of the perception and production of a second language: A progress report[1]

Robert McAllister and Mats Dufberg

Abstract

This paper is a progress report on a project dealing with L2 acquisition. The research work presented here is concerned with the ability of second language (L2) users to understand spoken L2. A test battery was administered to assess some relevant abilities. The battery includes: A psychoacoustic sub-battery including test of frequency discrimination, gap detection and signal-type discrimination; a word test with on-line fonological metrics to determine the phonological distance between the subject's answer and the target word; a top-down test using the phoneme monitoring paradigm; a global comprehension test and a pencil and paper self assessment test. These test results will be compared to an assessment of L2 speech production made by a large number of native listeners and related to several background factors.

1) McAllister and Dufberg, 1994.

Cross-language analysis of VCV coarticulation[1]

Michelle Molis[2], *Björn Lindblom*,
Wendy Castleman[2] *and René Carré*[3]

Abstract

Öhman[4] reported that superposition of a consonant closure gesture on a vowel-to-vowel transition was sufficient to describe VCV coarticulation; however, other researchers[5] have found a language-dependent articulatory trough in the movement of the tongue during some VCV sequences. Such a trough would limit the possible extent of coarticulation. In this study, one male speaker each of American English, French, and Swedish produced VCV sequences. Vowels included /i/, /a/ and /u/. For each of three stop consonants (/b/, /p/ and /d/), an index of coarticulation was obtained through calculation of a locus equation. In addition, coarticulation indices were obtained from the output of an acoustic tube model that uses superposition to generate VCV sequences. Preliminary results indicated that superposition alone predicted coarticulation of unaspirated stops in all languages, but was not sufficient to explain the reduced coarticulation observed for aspirated stops. Reduction in degree of coarticulation corresponded qualitatively with the language-dependent extent of the articulatory trough. With modifications intended to simulate an articulatory trough, the model successfully simulated the qualitative change in cross-linguistic coarticulation.

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1) Molis et al., 1994.
2) Department of Psychology, University of Texas, Austin Texas 78712, USA.
3) Département Signal, ENST, Paris, France.
4) Öhman, S. (1966): "Coarticulation in VCV utterances: Spectrographic measurements", in *J Acoust Soc Am*, **39** (1), 151–168.
5) McAllister, R. and O. Engstrand (1991):"Some cross language aspects of coarticulation", in *Perilus* **13**, 89–94.

Interaction between duration, context and speaking style in English stressed vowels[1]

Seung-Jae Moon[2] *and Björn Lindblom*

Abstract

Acoustic observations are reported for English front vowels embedded in a /w_l/ frame and carrying constant main stress. The vowels were produced by five speakers in clear and citation-form styles at varying durations but at a constant speaking rate. The acoustic analyses revealed: (i) that formant patterns were systematically displaced in the direction of the frequencies of the consonants of the adjacent pseudo-symmetrical context; (ii) that those displacements depended in a lawful manner on vowel duration; (iii) that this context- and duration-dependence was more limited for clear than for citation-form speech, and that the smaller formant shifts of clear speech tended to be achieved by increases in the rate of formant frequency change. The findings are compatible with a revised, and biomechanically motivated, version of the vowel undershoot model[3] that derives formant patterns from numerical information on three variables: the 'locus-target' distance, vowel duration and rate of formant frequency change. The results further indicate that the 'clear' samples were not merely louder, but involved a systematic, undershoot-compensating reorganization of the acoustic patterns.

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1) Moon and Lindblom, 1994.
2) Department of English, College of Liberal Arts, AJOU University, Suwon 441-749, Korea.
3) Lindblom, B. (1963): "Spectrographic study of vowel reduction", in *J Acoust Soc Am*, **35**, 1773–1781.

An acoustic study of vowel quality in spontaneous speech before and after glossectomy[1]

Eva Öberg

Abstract

The purpose of this study was to determine the formant frequencies of the Swedish tense vowels produced in spontaneous speech by four male speakers before and after non-total glossectomy, and to compare the post- with the preoperative vowel spaces on the F_1–F_2 plane. The speech material was collected from interviews with the subjects.

The postoperative vowels show a reduced F_2 range compared to the preoperative ones. This would reflect the glossectomee's inability to move an articulatory constriction horizontally. There is, however, no pre- vs. postoperative difference for F_1: the relatively unimpeded mobility of the jaw allows a certain flexibility in the high-low dimension.

The results do not give evidence of a general centralization of back and front vowels, but suggest different articulatory patterns for different speakers, depending on the amount of tongue tissue removed, and also on the mobility of the tongue remnant. In all four subjects a skin flap, retaining blood and nerve supply, has been sewn to the residual tongue tissue in order to restore as much mobility as possible. Two speakers subjected to radical resections of the back of their tongues show markedly centralized back vowels, but no pre- vs. postoperative difference for front vowels. This suggests a high mobility of their tongue remnants. In one speaker, who had been subjected to resection of a minor part of the back of the tongue, the skin flap necrotized and had to be removed. He shows normal frequencies for the back vowels but centralized front ones. This centralization is probably caused primarily by stiffness in the remaining tongue tissue. The postoperative F_2 range of the fourth speaker, who had been subjected to resection of the underside of the tongue and the floor of the mouth, suggests a slight centralization of both back and front vowels.

Despite the resections of tongue tissue and the reductions of the frequency range for the second formant, all four glossectomees are able to seperate the vowels acoustically. With all vowels plotted, the areas for the different phonemes show very little overlap.

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1) Öberg, 1993.

Speech after partial glossectomy: An articulatory study based on EPG data from two subjects[1]

Eva Öberg

Abstract

Speech following partial glossectomy is often perceptually judged as normal. To study whether the articulation of such patients is normal, or if compensatory strategies are employed, EPG data from two male glossectomees were analysed.

Subject G1 had undergone right hemiglossectomy and subject G2 resection of the underside of the tongue. In both cases the floor of the mouth had been resected. The hypoglossal and the lingual nerves had been cut off bilaterally in the latter patient. One normal speaker served as control subject.

Measurements were made at the articulatory point of maximum electrode activation of the consonants /t, d, n, s, ç, j, r, l/, each produced 12 times in the frame /taCVl/, where V = /i, a, u/.

The articulatory patterns of all consonants showed a leftright asymmetry. Only the fricatives, /s, ç, j/, exhibited a significantly more pronounced asymmetry for the glossectomees compared to the normal speaker. Place and width of the constriction of the fricatives was measured, defined as number of free electrodes in each row. For G2 the constriction was situated more posteriorly on the palate than for the normal speaker, and the groove was considerably wider. For G1, the patterns resembled those found for the normal subject. It was remarkable that he was able to produce /s/ with a narrow alveolar groove. The data suggest, however, that he did not form this groove with the tongue itself. Instead the air channel was situated beside the tongue on the right side, i.e. between the tongue and the teeth.

These results provide further evidence of the remarkable plasticity of speech apparatus. Despite hemiglossectomy, the palatolingual contact pattern of G1 is only slightly deviant from normal, and he is able to obtain normal groove dimensions for /s/ through articulatory reorganization. The articulatory pattern of G2 is more deviant from normal, but not to a degree that could be expected after a loss of the 12th nerve.

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1) Öberg, 1994a.

Cross-language differences in phonological acquisition: Swedish and American /t/[1]

Carol Stoel-Gammon,[2] *Karen Williams, and Eugene Buder*[2]

Abstract

Our understanding of phonological acquisition has benefited immensely from cross-linguistic investigations which allow researchers to separate biological and learned factors. To date, most cross-linguistic studies have focused either on differences in phonetic inventories or on differences in frequency of occurrence of particular phonetic and phonological properties in the adult language. This paper describes a third type of study: comparisons of segments that occur in two (or more) languages, but differ in their phonetic properties. We present perceptual and acoustic analyses of adult and child productions of word-initial alveolar /t/ in American English and dental /t/ in Swedish. Results showed that listeners' perception of place of articulation was strongly associated with language (alveolar: American English, dental: Swedish) for both adult and child tokens, and was effective in assigning individual speakers to language groups. Three acoustic measures, voice onset time (VOT), burst intensity and burst spectral diffuseness correlated with language for both child and adult tokens; the latter two measures correlated with perception as well. The findings suggest that American and Swedish children at 30 months of age have acquired some language-specific phonetic aspects of /t/ phonemes.

1) Stoel-Gammon et al., 1994.

2) Department of Speech and Hearing Sciences, University of Washington, Seattle, Washington, USA.

Word accent 2 in child directed speech: A pilot study[1]

Ulla Sundberg

Abstract

The tonal characteristics of disyllabic accent 2 words in child directed speech (CDS) were studied and compared to those in adult directed speech (ADS). The purpose of the study was to investigate 1) whether the secondary F0 rise is more prominent in CDS than in ADS, and 2) whether the secondary F0 rise is influenced more than the primary F0 fall in CDS.

Speech samples were obtained from one mother, speaking Central Standard Swedish, while interacting with her three month old son for about 15 minutes, and while she talked to the experimenter afterwards in a relaxed and informal discussion.

Disyllabic accent 2 words were identified in the speech samples. The words that were judged by the investigator to be the most prominent in each utterance are referred to as having sentence accent. An acoustic analysis was performed on words both with and without sentence accent determining the fall parameter in the first, primary stressed syllable and the rise parameter in the secondary stressed syllable.

The results showed that the mother drastically changed her speech style when addressing her infant. The main difference was the exaggerated tonal characteristics in the disyllabic accent 2 words. The results confirm the first hypothesis, i e the secondary F0 rise is more prominent in CDS than in ADS, especially in words without sentence accent. In ADS the fall parameter average was greater than the rise parameter average in words with sentence accent. The second hypothesis, that the secondary F0 rise is influenced more than the primary fall in CDS, was also supported. In particular, the F0 fall in the first syllable was seldom replaced by a F0 rise, whereas the F0 rise in the second syllable was realised as a F0 fall in many cases.

The results from this investigation may suggest that CDS is an important factor as linguistic input during the child's language acquisition process. However, the results from the present study must be regarded as preliminary since they are based on only one mother's speech.

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1) Sundberg, 1993b.

Tonal word accent 2 in Swedish speech directed to infants[1]

Ulla Sundberg

Abstract

Motherese (or child-directed speech) denotes a special speech style typically used by mothers and other care-takers in their interaction with infants. Prosodic modifications at sentence or phrase levels such as higher mean fundamental frequency, wider pitch excursions, tonally and temporally coherent intonation contours have been observed in a number of studies.[2] Such modifications are also likely to affect the intonation contour in the word domain. This paper reports an investigation of tonal and temporal aspects in disyllabic accent 2 words, produced by Swedish mothers in spontaneous interaction with their three-month-old infants. The child-directed speech data are contrasted with matching adult-directed speech data. Preliminary results are compatible with those from earlier studies. The results suggest that word emphasis is signaled differentially in infant-directed speech and adult-directed speech. Much wider pitch excursions were observed in the accent 2 words occurring in the former than in the latter case. In infant-directed speech, F0 may be the primary variable for marking prominence while in adult-directed speech duration seems to be the significant one.[3]

1) Sundberg, 1994a.
2) E.g. Fernald, A., T. Taeschner, J. Dunn, M. Papousek, B. Boysson-Bardie and I. Fukui (1989): "A cross-language study of prosodic modifications in mothers' and fathers' speech to preverbal infants", in *J. of Child Lang.* **16**, 477–501.
3) Sundberg, 1993b. Abstract also in this volume.

Tonal and temporal aspects of child directed speech[1]

Ulla Sundberg

Abstract
Disyllabic accent 2 words produced by three mothers interacting with their three month old infants and with an adult were investigated with respect to tonal and temporal characteristics. The F0 fall in the primary stressed first syllable and the F0 rise in the secondary stressed second syllable were measured in terms of pitch change, duration and the speed of the F0 change. The preliminary results support the hypothesis that the F0 rise in the secondary stressed syllable is significantly greater in speech directed to infants than in speech directed to adults. The results also support the hypothesis that the variability is greater in the secondary F0 rise in child directed speech than in the F0 fall in the primary stressed first syllable. A third hypothesis was that pitch and duration are used differentially in marking sentence accent in speech directed to infants and adults respectively. The preliminary results suggest individual strategies in this regard.

1) Sundberg, 1994b.

Swedish tonal word accent 2 in child directed speech – a pilot study of tonal and temporal characteristics[1]

Ulla Sundberg and Francisco Lacerda

Abstract

This study is based on a previous one by Sundberg (1993b) in which the extents of the F0 excursions in disyllabic accent 2 words were analysed in child directed speech (CDS) and in adult directed speech (ADS). The results showed a main effect of exaggeration of the tonal characteristics in CDS, when one mother addressed her three month old infant. The secondary F0 rise in the second syllable was more prominent in CDS than in ADS, especially in words with sentence accent, while no significant style difference was found in the fall parameter in words without sentence accent. This posed the question whether there is a difference with respect to durations. A comparison between the overall F0 contours revealed a strong difference between CDS and ADS. In CDS the F0 contours in words with and without sentence accent were very similar in their timing characteristics. The difference was in the range of the F0 changes during the fall and rise. In ADS, on the other hand, the timing was very different. In words with sentence accent the duration of the rise parameter was approximately 4 times longer than in words without sentence accent. The ranges of the F0 changes were rather moderate.

The results suggest a differential use of F0 and duration in marking sentence accent in CDS and ADS, respectively. In speech addressed to the infant the mother uses F0 variation in signalling sentence accent, while she uses variation in duration in the ADS.

The perceptual significance of the tonal and temporal exaggerations in CDS should be tested in formal experiments with infants.

1) Sundberg and Lacerda, 1993a.

Conventional, biological, and environmental factors in speech communication: A modulation theory[1]

Hartmut Traunmüller

Abstract

Speech signals contain various types of information that can be grouped under the headings phonetic, affective, personal, and transmittal. Listeners are capable of distinguishing these. Previous theories of speech perception have not considered this fully. They have mainly been concerned with problems relating to phonetic quality alone. The theory presented in this paper considers speech signals as the result of allowing conventional gestures to modulate a carrier signal that has the personal characteristics of the speaker, which implies that in general the conventional information can only be retrieved by demodulation.

1) Traunmüller, 1994.

The auditory perception of children's age and sex[1]

Hartmut Traunmüller and Renée van Bezooijen[2]

Abstract

Data on the accuracy with which listeners rate the age of children and some knowledge about the relative contributions of underlying factors (F_0, formant frequencies, 'verbal maturation') have been obtained in perceptual experiments using excerpts from interviews with children in the age groups 5, 7, 9, and 11 years. Utterances containing verbal cues to age were avoided by presenting written versions to a panel of judges. The utterances were LPC-analyzed and resynthesized with modifications, to obtain whispered speech, speech of 9 year olds with F_0, formants, and speech rate modified to suggest an age of 5, 7, 9, and 11 years, and whispered versions of these. The listeners agreed in their age ratings with an SD around 1.5 years. The differences between the four types of speech were small. The analysis showed the perceptual weight of the 'verbal maturation' factor to increase with experience, and that of F_0 to decrease. Data on sex recognition are presented without analysis of underlying factors.

1) Traunmüller and van Bezooijen, 1994.

2) Vakgroep Algemene Taalwetenschap en Dialectologie, Katholieke Universiteit Nijmegen

F_0-excursions in speech and their perceptual evaluation as evidenced in liveliness estimations[1]

Hartmut Traunmüller and Anders Eriksson

Abstract

Published data on F_0 in speech show its range of variation to be the same for men and women if expressed in semitones. An analysis of additional production data shows that the "liveliness" of speech is related to the extent of the excursions of F_0 from its "base-value". In order to learn how listeners evaluate F_0-excursions, a set of experiments was performed in which subjects had to estimate the liveliness of utterances. The stimuli were obtained by LPC-analysis of one natural utterance that was modified by resynthesizing F_0, the formant frequencies and the time scale in order to simulate some of the natural extra- and paralinguistic variations that affect F_0 and/or liveliness: The speaker's age, sex, articulation rate, and voice register. In each case, the extent of the F_0-excursions was varied in 7 steps. The results showed that, as long as no variation in voice register was involved, listeners judged F_0-intervals to be equal if they were equal in semitones. If the voice register was shifted without adjustment in articulation, listeners appeared to judge the F_0-excursions in relation to to the spectral space available below F_1. The liveliness ratings were found to be strongly dependent on articulation rate and they were observed to be affected by the perceived age of the speaker.

1) Traunmüller and Eriksson, 1993.

The perceptual evaluation of F0-excursions in speech as evidenced in liveliness estimations[1]

Hartmut Traunmüller and Anders Eriksson

Abstract

In order to learn how listeners evaluate F_0 excursions, a set of experiments was performed in which subjects had to estimate the liveliness of utterances. The stimuli were obtained by LPC analysis of one natural utterance that was modified by resynthesizing F_0, the formant frequencies, and the time scale in order to simulate some of the natural extra- and paralinguistic variations that affect F_0 and/or liveliness, namely the speaker's age, sex, articulation rate, and voice register. In each case, the extent of the F_0 excursions was varied in seven steps. The results showed that, as long as no variation in voice register was involved, listeners judged F_0 intervals to be equal if they were equal in semitones. Since investigations of F_0 in speech have shown its range of variation expressed in semitones to be approximately the same for men and women, this implies that the degree of liveliness in typical speech of men and women is the same. When the voice register was shifted without adjustment in articulation, listeners appeared to judge the F_0 excursions in relation to the spectral space available below F_1. The liveliness ratings were found to be strongly dependent on articulation rate and to be affected by the perceived age of the speaker which, with the manipulated stimuli used here, turned out to be significantly affected by the sex of the *listener*.

1) Traunmüller and Eriksson, 1995.

External sources of individual differences? A cross-linguistic analysis of the phonetics of maternal speech to one-year-old children[1]

Marilyn Vihman,[2] *Edwin Kay,*[3]
Bénédicte de Boysson-Bardie,[4]
Catherine Durand,[4] *and Ulla Sundberg*

Abstract

This study deals with the possible differential effect on the children of exposure to different samples of input speech within the same language community. The role of specific adult input in interchild production variability was investigated by analyzing samples of American, French and Swedish mothers talking to their one-year-old children. This study analyzed the distribution of consonantal categories, word length, and final consonants in running speech, content words, initial consonant of content words, and target words (adult models of words attempted by the children) and also the children's early words.

The findings suggest that, for most purposes, a sample of the target words attempted by a group of 5 or more children may be viewed as representative of the adult language.

The results also showed that children's word productions are consistently more variable than the mother's speech and that there were no evidence of specific maternal influence on the phonetics of the child's speech.

The high variability of different children's words shapes reflects the individuality of a matching process: Each child attends to the input speech patterns afforded by the ambient language with a unique filter, on the basis of emergent production patterns.

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Previous issues of Perilus

PERILUS I, 1978–1979

Introduction *Björn Lindblom and James Lubker*

Vowel identification and spectral slope *Eva Agelfors and Mary Gräslund*

Why does [ɑ] change to [o] when F_0 is increased? Interplay between harmonic structure and formant frequency in the perception of vowel quality *Åke Florén*

Analysis and prediction of difference limen data for formant frequencies *Lennart Nord and Eva Sventelius*

Vowel identification as a function of increasing fundamental frequency *Elisabeth Tenenholtz*

Essentials of a psychoacoustic model of spectral matching *Hartmut Traunmüller*

Interaction between spectral and durational cues in Swedish vowel contrasts *Anette Bishop and Gunilla Edlund*

On the distribution of [h] in the languages of the world: is the rarity of syllable final [h] due to an asymmetry of backward and forward masking? *Eva Holmberg and Alan Gibson*

On the function of formant transitions: I. Formant frequency target vs. rate of change in vowel identification, II. Perception of steady vs. dynamic vowel sounds in noise *Karin Holmgren*

Artificially clipped syllables and the role of formant transitions in consonant perception *Hartmut Traunmüller*

The importance of timing and fundamental frequency contour information in the perception of prosodic categories *Bertil Lyberg*

Speech perception in noise and the evaluation of language proficiency *Alan C. Sheats*

BLOD — A block diagram simulator *Peter Branderud*

PERILUS II, 1979--1980

Introduction *James Lubker*

A study of anticipatory labial coarticulation in the speech of children *Åsa Berlin, Ingrid Landberg and Lilian Persson*

Rapid reproduction of vowel–vowel sequences by children *Åke Florén*

Production of bite-block vowels by children *Alan Gibson and Lorrane McPhearson*

Laryngeal airway resistance as a function of phonation type *Eva Holmberg*

The declination effect in Swedish *Diana Krull and Siv Wandebäck*

Compensatory articulation by deaf speakers *Richard Schulman*

Neural and mechanical response time in the speech of cerebral palsied subjects *Elisabeth Tenenholtz*

An acoustic investigation of production of plosives by cleft palate speakers *Gärda Ericsson*

PERILUS III, 1982--1983

Introduction *Björn Lindblom*

Elicitation and perceptual judgement of disfluency and stuttering *Anne-Marie Almé*

Intelligibility vs. redundancy – conditions of dependency *Sheri Hunnicut*

The role of vowel context on the perception of place of articulation for stops *Diana Krull*

Vowel categorization by the bilingual listener *Richard Schulman*

Comprehension of foreign accents. (A Cryptic investigation.) *Richard Schulman and Maria Wingstedt*

Syntetiskt tal som hjälpmedel vid korrektion av dövas tal *Anne-Marie Öster*

PERILUS IV, 1984–1985

Introduction *Björn Lindblom*

Labial coarticulation in stutterers and normal speakers *Ann-Marie Almé and Robert McAllister*

Movetrack *Peter Branderud*

Some evidence on rhythmic patterns of spoken French *Danielle Dueza and Yukihoro Nishinuma*

On the relation between the acoustic properties of Swedish voiced stops and their perceptual processing *Diana Krull*

Descriptive acoustic studies for the synthesis of spoken Swedish *Francisco Lacerda*

Frequency discrimination as a function of stimulus onset characteristics *Francisco Lacerda*

Speaker–listener interaction and phonetic variation *Björn Lindblom and Rolf Lindgren*

Articulatory targeting and perceptual consistency of loud speech *Richard Schulman*

The role of the fundamental and the higher formants in the perception of speaker size, vocal effort, and vowel openness *Hartmut Traunmüller*

PERILUS V, 1986–1987

About the computer-lab *Peter Branderud*

Adaptive variability and absolute constancy in speech signals: two themes in the quest for phonetic invariance *Björn Lindblom*

Articulatory dynamics of loud and normal speech *Richard Schulman*

An experiment on the cues to the identification of fricatives *Hartmut Traunmüller and Diana Krull*

Second formant locus patterns as a measure of consonant–vowel coarticulation *Diana Krull*

Exploring discourse intonation in Swedish *Madeleine Wulffson*

Why two labialization strategies in Setswana? *Mats Dufberg*

Phonetic development in early infancy – a study of four Swedish children during the first 18 months of life *Liselotte Roug, Ingrid Landberg and Lars Johan Lundberg*

A simple computerized response collection system *Johan Stark and Mats Dufberg*

Experiments with technical aids in pronunciation teaching *Robert McAllister, Mats Dufberg and Maria Wallius*

PERILUS VI, Fall 1987 (Ph.D. thesis)

Effects of peripheral auditory adaptation on the discrimination of speech sounds
Francisco Lacerda

PERILUS VII, May 1988 (Ph.D. thesis)

Acoustic properties as predictors of perceptual responses: a study of Swedish voiced stops
Diana Krull

PERILUS VIII, December 1988

Some remarks on the origin of the "phonetic code" *Björn Lindblom*

Formant undershoot in clear and citation form speech *Björn Lindblom and Seung-Jae Moon*

On the systematicity of phonetic variation in spontaneous speech *Olle Engstrand and Diana Krull*

Discontinuous variation in spontaneous speech *Olle Engstrand and Diana Krull*

Paralinguistic variation and invariance in the characteristic frequencies of vowels *Hartmut Traunmüller*

Analytical expressions for the tonotopic sensory scale *Hartmut Traunmüller*

Attitudes to immigrant Swedish – A literature review and preparatory experiments *Una Cunningham-Andersson and Olle Engstrand*

Representing pitch accent in Swedish *Leslie M. Bailey*

PERILUS IX, February 1989

Speech after cleft palate treatment – analysis of a 10-year material *Gärda Ericsson and Birgitta Ystrom*

Some attempts to measure speech comprehension *Robert McAllister and Mats Dufberg*

Speech after glossectomy: phonetic considerations and some preliminary results *Ann-Marie Almé and Olle Engstrand*

PERILUS X, December 1989

F0 correlates of tonal word accents in spontaneous speech: range and systematicity of variation *Olle Engstrand*

Phonetic features of the acute and grave word accents: data from spontaneous speech. *Olle Engstrand*

A note on hidden factors in vowel perception experiments *Hartmut Traunmüller*

Paralinguistic speech signal transformations *Hartmut Traunmüller, Peter Branderud and Aina Bigestans*

Perceived strength and identity of foreign accent in Swedish *Una Cunningham-Andersson and Olle Engstrand*

Second formant locus patterns and consonant–vowel coarticulation in spontaneous speech *Diana Krull*

Second formant locus – nucleus patterns in spontaneous speech: some preliminary results on French *Danielle Duez*

Towards an electropalatographic specification of consonant articulation in Swedish. *Olle Engstrand*

An acoustic-perceptual study of Swedish vowels produced by a subtotally glossectomized speaker *Ann-Marie Almé, Eva Öberg and Olle Engstrand*

PERILUS XI, May 1990

In what sense is speech quantal? *Björn Lindblom and Olle Engstrand*

The status of phonetic gestures *Björn Lindblom*

On the notion of "Possible Speech Sound" *Björn Lindblom*

Models of phonetic variation and selection *Björn Lindblom*

Phonetic content in phonology *Björn Lindblom*

PERILUS XII, May 1991

On the communicative process: Speaker–listener interaction and the development of speech *Björn Lindblom*

Conversational maxims and principles of language planning *Hartmut Traunmüller*

Quantity perception in Swedish [VC]-sequences: word length and speech rate. *Hartmut Traunmüller and Aina Bigestans*

Perceptual foreign accent: L2 user's comprehension ability *Robert McAllister*

Sociolectal sensitivity in native, non-native and non speakers of Swedish – a pilot study *Una Cunningham-Andersson*

Perceptual evaluation of speech following subtotal and partial glossectomy *Ann-Marie Almé*

VOT in spontaneous speech and in citation form words *Diana Krull*

Some evidence on second formant locus-nucleus patterns in spontaneous speech in French *Daniell Duez*

Vowel production in isolated words and in connected speech: an investigation of the linguo-mandibular subsystem *Edda Farnetani and Alice Faber*

Jaw position in English and Swedish VCVs *Patricia A. Keating, Björn Lindblom, James Lubker, and Jody Kreiman*

Perception of CV-utterances by young infants: pilot study using the High-Amplitude-Sucking technique *Francisco Lacerda*

Child adjusted speech *Ulla Sundberg*

Acquisition of the Swedish tonal word accent contrast *Olle Engstrand, Karen Williams, and Sven Strömquist*

PERILUS XIII, May 1991 (Papers from the Fifth National Phonetics Conference, Stockholm, May 29–31, 1991)

Initial consonants and phonation types in Shanghai *Jan-Olof Svantesson*

Acoustic features of creaky and breathy voice in Udehe *Galina Radchenko*

Voice quality variations for female speech synthesis *Inger Karlsson*

Effects of inventory size on the distribution of vowels in the formant space: preliminary data from seven languages *Olle Engstrand and Diana Krull*

The phonetics of pronouns *Raquel Willerman and Björn Lindblom*

Perceptual aspects of an intonation model *Eva Gårding*

Tempo and stress *Gunnar Fant, Anita Kruckenberg, and Lennart Nord*

On prosodic phrasing in Swedish *Gösta Bruce, Björn Granström, Kjell Gustafson and David House*

Phonetic characteristics of professional news reading *Eva Strangert*

Studies of some phonetic characteristics of speech on stage *Gunilla Thunberg*

The prosody of Norwegian news broadcasts *Kjell Gustafson*

Accentual prominence in French: read and spontaneous speech *Paul Touati*

Stability of some Estonian duration relations *Diana Krull*

Variation of speaker and speaking style in text-to-speech systems *Björn Granström and Lennart Nord*

Child adjusted speech: remarks on the Swedish tonal word accent *Ulla Sundberg*

Motivated deictic forms in early language acquisition *Sarah Williams*

Cluster production at grammatical boundaries by Swedish children: some preliminary observations *Peter Czigler*

Infant speech perception studies *Francisco Lacerda*

Reading and writing processes in children with Down syndrome – a research project *Iréne Johansson*

Velum and epiglottis behaviour during production of Arabic pharyngeals: a fibroscopic study *Ahmed Elgendi*

Analysing gestures from X-ray motion films of speech *Sidney Wood*

Some cross language aspects of co-articulation *Robert McAllister and Olle Engstrand*

Articulation inter-timing variation in speech: modelling in a recognition system *Mats Blomberg*

The context sensitivity of the perceptual interaction between F0 and F1 *Hartmut Traunmüller*

On the relative accessibility of units and representations in speech perception *Kari Suomi*

The QAR comprehension test: a progress report on test comparisons *Mats Dufberg and Robert McAllister*

Phoneme recognition using multi-level perceptrons *Kjell Elenius och G. Takács*

Statistical inferencing of text–phonemics correspondences *Bob Damper*

Phonetic and phonological levels in the speech of the deaf *Anne-Marie Öster*

Signal analysis and speech perception in normal and hearing-impaired listeners *Annica Hovmark*

Speech perception abilities of patients using cochlear implants, vibrotactile aids and hearing aids *Eva Agelfors and Arne Risberg*

On hearing impairments, cochlear implants and the perception of mood in speech *David House*

Touching voices – a comparison between the hand, the tactilator and the vibrator as tactile aids *Gunilla Öhngren*

Acoustic analysis of dysarthria associated with multiple sclerosis – a preliminary note *Lena Hartelius and Lennart Nord*

Compensatory strategies in speech following glossectomy *Eva Öberg*

Flow and pressure registrations of alaryngeal speech *Lennart Nord, Britta Hammarberg, and Elisabet Lundström*

PERILUS XIV, December 1991
(Papers from the symposium Current phonetic research paradigm: Implications for speech motor control, Stockholm, August 13–16, 1991)

Does increasing representational complexity lead to more speech variability? *Christian Abry and Tahar Lallouache*

Some cross language aspects of co-articulation *Robert McAllister and Olle Engstrand*

Coarticulation and reduction in consonants: comparing isolated words and continuous speech *Edda Farnetani*

Trading relations between tongue-body raising and lip rounding in production of the vowel /u/ *Joseph S. Perkell, Mario A. Svirsky, Melanie L. Matthies and Michael I. Jordan*

Tongue-jaw interactions in lingual consonants *B Kühnert, C Ledl, P Hoole and H G Tillmann*

Discrete and continuos modes in speech motor control *Anders Löfqvist and Vincent L. Gracco*

Paths and trajectories in orofacial motion *D.J. Ostry, K.G. Munhall, J.R. Flanagan and A.S Bregman*

Articulatory control in stop consonant clusters *Daniel Recasens, Jordi Fontdevila and Maria Dolors Pallares*

Dynamics of intergestural timing *E. Saltzman, B. Kay, P. Rubin and J. Kinsella-Shaw*

Modelling the speaker–listener interaction in a quantitative model for speech motor control: a framework and some preliminary results *Rafael Laboissiere, Jean-Luc Schwartz and Gérard Bailly*

Neural network modelling of speech motor control using physiological data *Eric Vatikiotis-Bateson, Makoto Hirayama and Mitsuo Kawato*

Movement paths: different phonetic contexts and different speaking styles *Celia Scully, Esther Grabe-Georges and Pierre Badin*

Speech production. From acoustic tubes to the central representation *René Carré and Mohamed Mrayati*

On articulatory and acoustic variabilities: implications for speech motor control *Shinji Maeda*

Speech perception based on acoustic landmarks: implications for speech production *Kenneth N. Stevens*

An investigation of locus equations as a source of relational invariance for stop place categorization *Harvey M. Sussman*

A first report on consonant underarticulation in spontaneous speech in French *Danielle Duez*

Temporal variability and the speed of time's flow *Gerald D. Lame*

Prosodic segmentation of recorded speech *W.N. Campbell*

Rhythmical – in what sense? Some preliminary considerations *Lennart Nord*

Focus and phonological reduction *Linda Shockey*

Recovery of "deleted" schwa *Sharon Y. Manuel*

Invariant auditory patterns in speech processing: an explanation for normalization *Natalie Waterson*

Function and limits of the F1:F0 covariation in speech *Hartmut Traunmüller*

Psychoacoustic complementarity and the dynamics of speech perception and production *Keith R. Kluender*

How the listener can deduce the speaker's intended pronunciation *John J. Ohala*

Phonetic covariation as auditory enhancement: the case of the [+voice]/[–vocie] distinction *Randy L. Diehl and John Kingston*

Cognitive-auditory constraints on articulatory reduction *Klaus J. Kohler*

Words are produced in order to be perceived: the listener in the speaker's mind *Sieb G. Nooteboom*

An acoustic and perceptual study of undershoot in clear and citation-form speech *Seung-Jae Moon*

Phonetics of baby talk speech: implications for infant speech perception *Barbara Davis*

Use of the sound space in early speech *Peter F. MacNeilage*

The emergence of phonological organization *M.M. Vihman and L. Roug-Hellichius*

In defense of the Motor Theory *Ignatius G. Mattingly*

Learning to talk *Michael Studdert-Kennedy*

PERILUS XV, December 1992

Use of place and manner dimension in the SUPERB UPSID database: Some patterns of in(ter)dependence *Björn Lindblom, Diana Krull and Johan Stark*

Comparing vowel formant data cross-linguistically *Diana Krull and Björn Lindblom*

Temporal and tonal correlates to quantity in Estonian *Diana Krull*

Some evidence that perceptual factors shape assimilations *Susan Hura, Björn Lindblom and Randy Diehl*

Focus and phonological reduction *Linda Shockey, Kristyan Spelman Miller and Sarah Newson*

The Phonetics of sign language; an outline of a project (paper in Swedish, summary in English) *Catharina Kylander*

The role of the jaw in constriction adjustments during pharyngeal and pharyngealized articulation *Ahmed M. Elgendy*

Young infants prefer high/low vowel contrasts *Francisco Lacerda*

Young infant's discrimination of confusable speech signals *Francisco Lacerda*

Dependence of high-amplitude sucking discrimination results on the pre- and post-shift window duration *Francisco Lacerda*

Prototypical vowel information in baby talk *Barbara Davis and Björn Lindblom*

PERILUS XVI, May 1993 (Ph.D. thesis)

Aerodynamic measurements of normal voice *Eva Holmberg*

PERILUS XVII, December 1993

F_0-excursions in speech and their perceptual evaluation as evidenced in liveliness estimations *Hartmut Traunmüller and Anders Eriksson*

Quality judgements by users of text-to-speech synthesis as a handicap aid *Olle Engstrand*

Word-prosodic features in Estonian conversational speech: some preliminary results *Diana Krull*

Sonority contrasts dominate young infants' vowel perception *Francisco Lacerda*

Word accent 2 in child directed speech: A pilot study *Ulla Sundberg*

Swedish tonal word accent 2 in child directed speech — a pilot study of tonal and temporal characteristics *Ulla Sundberg and Francicso Lacerda*

Stigmatized pronunciations in non-native Swedish *Una Cunningham-Andersson*

PERILUS XVIII, June 1994

Conventional, biological, and environmental factors in speech communication: A modulation theory *Hartmut Traunmüller*

Cross-language differences in phonological acquisition: Swedish and American /t/ *Carol Stoel-Gammon, Karen Williams and Eugene Buder*

Durational correlates of quantity in Swedish, Finnish and Estonian: cross-language evidence for a theory of adaptive dispersion *Olle Engstrand and Diana Krull*

Acoustics and perception of Estonian vowel types *Arvo Eek and Einar Meister*

Methodological studies of Movetrack — coil tilt and placement *Peter Branderud, Robert McAllister and Bo Kassling*