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ANNUAL REPORT

of the
Institute of Phonetics
University of Copenhagen

COPENHAGEN 1975

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KØBENHAVNS UNIVERSITET
OFFSET AFDELINGEN

PERSONNEL OF THE INSTITUTE OF PHONETICS
1974

Permanent Staff:

Professor:

Eli Fischer-Jørgensen (director of the Institute)

Lecturers:

Jørgen Rischel, dr.phil. (on leave from August 1)
Oluf M. Thorsen
Børge Frøkjær-Jensen
Hans Basbøll
Nina Thorsen
Peter Holtse
Steffen Heger (from April 1)
Anders Löfqvist (from August 1)

Technical Staff:

Mogens Møller (M.Sc.)
Preben Dømler (B.Sc.)
Svend-Erik Lystlund (technician)
Else Parkmann (secretary)

Part Time Teachers:

Peter Molbæk Hansen
John Jørgensen
Carl Ludvigsen (M.Sc.)
Ellen Pedersen
Niels Reinholt Petersen
Pia Riber Petersen

Guests:

Several phoneticians from a number of countries have worked at the laboratory during a shorter or longer period of time, including: Niels Bak (Aarhus, Denmark), Claus Bang (Aalborg, Denmark), A. Hirose (Japan), Jørgen Jørgensen (Aarhus, Denmark), Philip Mansell (United Kingdom), Svend Smith (Federal Republic of Germany), Tomás Szende (Hungary), and Elizabeth Uldall (United Kingdom). Furthermore, a number of phoneticians, speech therapists, and polytechnicians have visited the laboratory.

PUBLICATIONS BY STAFF MEMBERS 1974:

Hans Basbøll:	"Structure consonantique du mot italien", Revue Romane IX, p. 27-40
Hans Basbøll:	"The syllable in a generative phonology", Papers from the First Meeting of Scandinavian Linguists, Kungälv (ed. Östen Dahl), p. 37-56
Steffen Heger:	Sprog og lyd. Elementær dansk fonetik I. Fidus-serien, Sprog og Litteratur (Gjellerup), 77 pp.
Jørgen Rischel:	Topics in West Greenlandic Phonology (dissertation) (Akademisk forlag), 478 pp.
O. Kongsdal, K. Landschultz, O. Thorsen:	Fransk Fonetik, revised edition (Københavns Universitets Offset-trykafdeling), 251 pp.

LECTURES AND COURSES IN 1974

1. Elementary phonetics courses

One-semester courses (two hours a week) in elementary phonetics (intended for all students of foreign languages except French) were given by Hans Basbøll/Eli Fischer-Jørgensen, Peter Molbæk Hansen, Steffen Heger, Peter Holtse, Birgit Hutters, Ellen Pedersen, Niels Reinholt Petersen, Pia Riber Petersen, and Nina Thorsen.

There was one class in the spring semester, and 20 parallel classes in the autumn semester.

Courses in general and French phonetics for students of French (two/three hours a week in two semesters) were given through 1974 by Oluf M. Thorsen.

2. Practical training in sound perception and transcription

Courses for beginners as well as courses for more advanced students were given through 1974 by Steffen Heger and Oluf M. Thorsen. (The courses which are based in part on tape recordings and in part on work with informants, form a cycle of three semesters with two hours a week.)

3. Instrumental phonetics

Courses for beginners as well as courses for more advanced students were given by Peter Holtse, Mogens Møller and Nina Thorsen in the spring semester (experimental acoustic phonetics and experimental physiological phonetics), and in the autumn semester by Peter Holtse and Nina Thorsen (registration of the intensity and fundamental frequency of speech).

4. Phonology

Jørgen Rischel and Hans Basbøll gave courses for beginners and advanced students. (The courses for beginners now form a cycle of two semesters with two hours a week. The contents are: problems in phonology and trends in phonological schools.)

5. Other courses

Eli Fischer-Jørgensen gave a course in German phonetics, held seminars on experimental phonetics, and gave a course in auditory test methods.

Oluf Thorsen gave a course in French phonetics.

Hans Basbøll gave a course in Danish phonology and phonetics.

Nina Thorsen gave a course in English phonetics.

Anders Löfqvist gave a course in the physiology of the speech organs.

Henning Spang-Hanssen (Institute of Applied and Mathematical Linguistics) gave a course in elementary statistics.

Carl Ludvigsen gave a course in advanced statistics.

Esther Dinsen (Institute of Applied and Mathematical Linguistics) gave a course in the theory and practice of the language laboratory.

6. Seminars

The following seminars were held in 1974:

Niels Davidsen-Nielsen lectured on phonological problems in the analysis of English (Germanic) sp, st, sk, and reported on his tests on "slips of the tongue".

Tamás Szende (Budapest): Intra- und interlinguale Spezifika in Verteilungsverhältnissen spontaner Sprechvorgänge.

Hans Basbøll presented his notes on Danish phonology.

Børge Frøkjær-Jensen, Peter Holtse, Anders Löfqvist and Nina Thorsen gave an account of their impressions from the symposium on speech communication in Stockholm.

Birgit Hutters and Jørgen Rischel reported on their experiences with glottography and fiber optics.

Martin Kloster Jensen (Bergen) lectured on "Articues".

Wolfgang Dressler (Vienna) presented a paper on the psycho-sociological treatment of phonological variation.

Benny Brodda (Stockholm) lectured on natural phonotactics.

A.C. Gimson (London) presided at a discussion on the teaching of pronunciation.

Mogens Møller and Peter Holtse gave an account of the configuration of the computer of the institute and discussed possible uses of a computer in phonetic research.

Peter Molbæk Hansen and Bent Møller presented an acoustic study of the coalescence of /a/ and /ɛ/ after /r/ in Advanced Copenhagen speech.

7. Participation in congresses and lectures at other institutions visited by members of the staff

Hans Basbøll participated in the First Scandinavian Meeting of Linguistics at Kungälv, Sweden, in March and gave a paper on "The syllable in Danish phonology".

Børge Frøkjær-Jensen gave a paper on methods for instrumental examination at a senior course in phoniatrics at Kolle Kolle in May.

Børge Frøkjær-Jensen, Peter Holtse, and Nina Thorsen participated in the Speech Communication Seminar in Stockholm in August.

Hans Basbøll, Preben Dømler, Eli Fischer-Jørgensen, Steffen Heger, Peter Holtse, Svend-Erik Lystlund, and Nina Thorsen participated in a symposium of phoneticians at the

University of Stockholm in September, and reported on research in progress at the Institute of Phonetics.

Børge Frøkjær-Jensen participated in the First Colloquium on phoniatric laryngology at Utrecht in November, and gave a paper: "Survey and demonstration of the instrumental possibilities for phoniatrics and phonetics".

INSTRUMENTAL EQUIPMENT OF THE LABORATORY

The following is a list of the instruments that have been purchased or built since January 1st, 1974.

1. Tape recorder

1 semi-professional recorder, Revox, type A77.

1 professional recorder, Revox, type A700.

2. Equipment for EDP

1 teletype, Teletype, type ASR 33

3. Instrumentation for visual recordings

1 oscilloscope, Tektronix, type 5115

1 dual-trace amplifier, Tektronix, type 5A18N

1 time-base, Tektronix, type 5B10N

4. Loudspeaker/headphones

2 headphones, Sennheiser, type HD 414

(ARIPUC 9, 1975)

A SURVEY ON THE COMPOSITION OF A MINICOMPUTER SYSTEM IN THE LABORATORY

Mogens Møller

1. Introduction

In January 1973 a minicomputer, PDP/8e with operator's console (DECwriter LA30) was installed in the laboratory. Since then the computer system has been expanded with several peripherals, some bought from computer equipment suppliers, others constructed in the laboratory.

2. System description

The computer with its peripherals now compose a rather powerful system for calculations, on-line data acquisition and signal processing.

The present system consists of:

PDP/8e Central Processing Unit	(CPU)
8k of core memory	
Extended Arithmetic Element	(EAE)
Paper Tape Reader	(PTR)
Paper Tape Puncher	(PTP)
Operator's Console (typewriter)	(LA30)
Teletype (typewriter)	(TTY)
Dual DECtape	(DTA)
Real Time Clock	(RTC)
Analog-to-Digital Converter	(ADC)
Digital-to-Analog Converter	(DAC)

The configuration with the possible data and control paths are shown in figure 1.

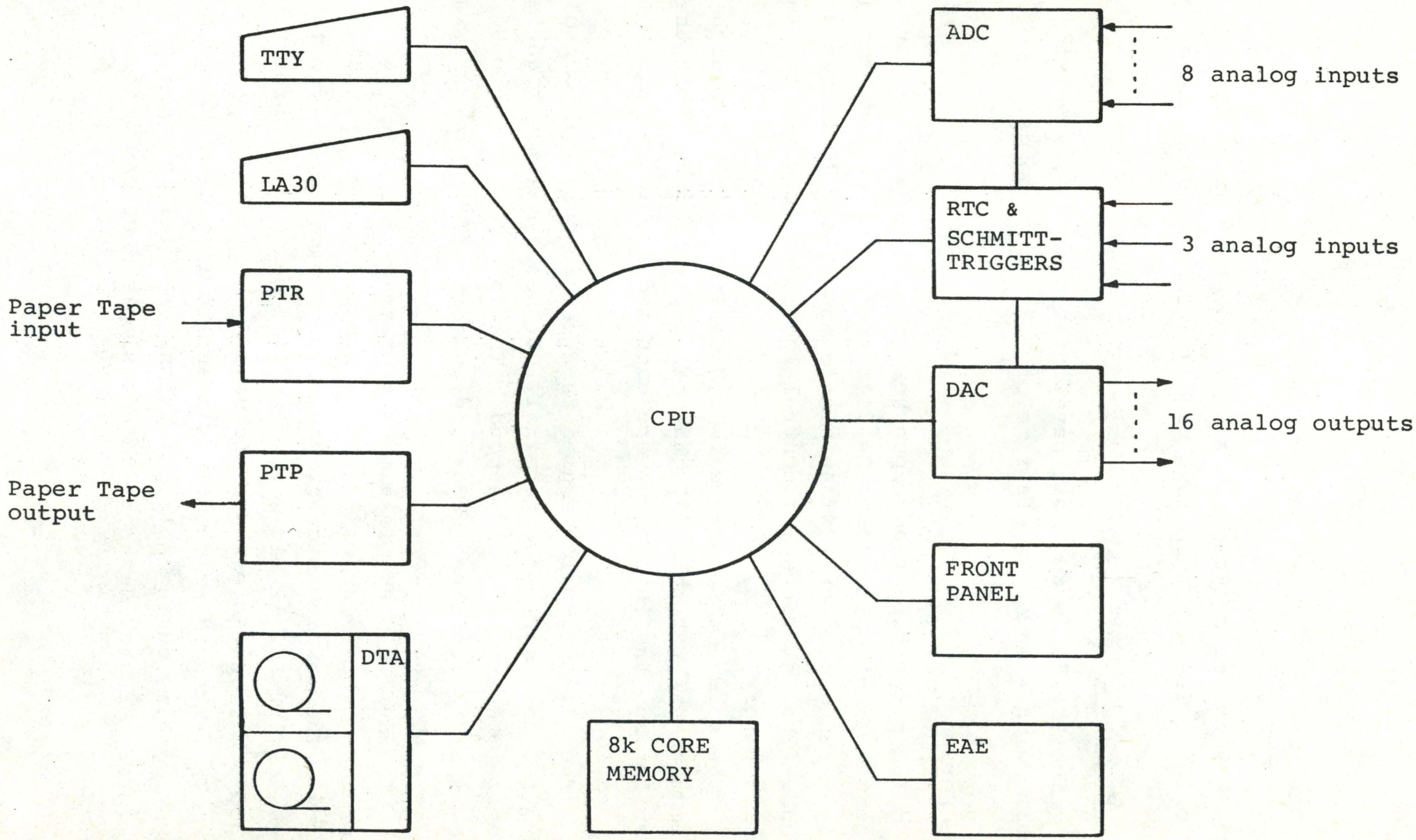

Fig. 1 System configuration.

3. Hardware

A short description of the equipment is given in the following. The abbreviations used are those listed above.

3.1 Processor

The PDP/8e is a 12 bit parallel synchronously working machine with a memory cycle time of 1.2 microseconds.

3.2 Peripherals

The paper tape reader/puncher appears as a self-starting reader (GNT Automatic model 24), 40 frames per second, and a self-starting puncher (GNT Automatic model 34), 70 frames per second. The interface and control logic were constructed in the laboratory.

The operator's console is a DECwriter model LA30 with a maximum transfer rate of 30 characters per second. Both the DECwriter and the interface were supplied by Digital Equipment Corporation.

The Teletype will be used as a remote operating console and off-line programming terminal. It has a maximum transfer rate of 10 characters per second. The Teletype is equipped with a low speed paper tape reader and puncher. The interface was built in the laboratory.

The dual DECtape is a mass storage device which can be used as program library as well as data storage or as a virtual memory. The maximum storage capacity on each of the two tape drives is 188,672 12 bit words, and the maximum transfer rate is 33,300 3 bit characters per second.

The Extended Arithmetic Element is installed to minimize computing time during multiplications and divisions. Furthermore, the EAE provides some rather simple double precision operating features.

The Real Time Clock, the Analog-to-Digital Converter and the Digital-to-Analog Converter are interconnected and thus constitute a set of very powerful input/output media for signal processing.

The RTC is a standard DEC supplied DK8-EP Programmable Real Time Clock, which includes three Schmitt trigger circuits monitoring three analog inputs. The RTC is controlled by the CPU, i.e. by the program executed in the computer. Under program control the RTC can trigger the CPU, the ADC, or the DAC with trigger-frequencies between 0.024414 Hz and 1 MHz. Furthermore, the RTC can be used for measuring time intervals between external events, detected by the Schmitt trigger inputs.

To minimize time jitter during sampling lapses the connection between the RTC and the ADC - or between the RTC and the DAC - can carry the trigger-pulses, which means that the timing of the sampling can be made totally independent of the CPU (within certain frequency limits).

The ADC is a standard DEC supplied AD8-EA Analog-to-Digital Converter with a AM8-EA 8 Channel Analog Multiplexer. The sample acquisition time is approximately 3 microseconds, and the conversion time is 20 microseconds. The multiplexer allows the ADC to be connected to any of the 8 differential-input amplifiers which have an input voltage range from -1 to +1 volt.

The DAC was designed and built in the laboratory as a general purpose DAC. However, great care has been taken in the design to make the DAC well suited as interface between the PDP/8e and the speech synthesizer constructed in this laboratory during the years 1966 to 1972 by J. Rischel and S.E. Lystlund (see particularly Rischel 1967 and Rischel and Lystlund 1972). These considerations have been decisive in the choice of the number of channels, the output range and some of the special features of the DAC which are too complex to be described in all details here.

The DAC appears as a 16 channel 10 bit converter with digital demultiplexer. The settling time for each converter is less than 10 microseconds, and the output voltage range goes from -10 to +10 volts. The demultiplexer and the data-loading logic can be controlled individually.

One of the special DAC features should be mentioned. The demultiplexer logic may be set in an autoincremental-mode, i.e. every data-loading instruction will cause an incrementing of the demultiplexer within a certain "loop limit" which may be set initially. This means that a preset loop, e.g. channels 0 - 8, will be scanned automatically just by repetitive data-loading instructions. By means of this feature an arbitrary number of channels (less than 17, of course) may be scanned with maximum speed. The logic allows the programmer to load DAC-channels outside the loop without disturbing the loop setting.

4. Software

To take full advantage of the peripherals it is necessary to write the programs in machine code or assembler language. However, a program library is being established. Several programs are already available, e.g. assembler-coded routines to handle certain peripherals, routines which can be called as subroutines from programs written in FORTRAN II, subroutines for high precision calculations, and programs for statistic calculations.

The program library is still expanding. It can be mentioned that a rather complex system of programs for sampling and signal-processing of electromyographic recordings is under development. The development of programs to control the speech synthesizer has been planned for some time, and the implementation has recently started.

A number of programs are available as programming aids: Editors, compilers (FORTRAN, FOCAL, BASIC), assemblers, loaders and debugging programs.

These utility programs are part of an operating system which makes communication with the machine very simple.

References

Rischel, Jørgen 1967: "Instrumentation for vowel synthesis", ARIPUC 1/1966, p. 15-21

Rischel, Jørgen and Svend-Erik Lystlund 1972: "A Formant-coded speech synthesizer", ARIPUC 6, p. IX-XXIX

ABBREVIATIONS EMPLOYED IN REFERENCES

AJPs. American Journal of Psychology

AL Acta Linguistica

ALH Acta Linguistica Hafniensia

ARIPUC Annual Report of the Institute of Phonetics, University of Copenhagen

Folia Ph. Folia Phoniatrica

FRJ For Roman Jakobson

F&S Form and Substance

Haskins SR Status Report on Speech Research, Haskins Laboratories

IJAL International Journal of American Linguistics

IPO IPO Annual Progress Report

JASA Journal of the Acoustical Society of America

JL Journal of Linguistics

JPh Journal of Phonetics

JSHD Journal of Speech and Hearing Disorders

JSHR Journal of Speech and Hearing Research

Lg. Language

Ling. Linguistics

LS Language and Speech

MIT QPR M.I.T. Quarterly Progress Report

NTTS Nordisk Tidsskrift for Tale og Stemme

Proc. Acoust. ... Proceedings of the ... International Congress on Acoustics

Proc. Ling. ... Proceedings of the ... International Congress of Linguists

Proc. Phon. ... Proceedings of the ... International Congress of Phonetic Sciences

STL-QPSR Speech Transmission Laboratories, Quarterly Progress and Status Report

SL Studia Linguistica

SPE The Sound Pattern of English

TCLC Travaux du Cercle Linguistique de Copenhague

TCLP Travaux du Cercle Linguistique de Prague

UCLA Working Papers in Phonetics, University of California

Zs.f.Ph. Zeitschrift für Phonetik, Sprachwissenschaft und Kommunikationsforschung

(ARIPUC 9, 1975)

ASYMMETRIC VOWEL HARMONY IN GREENLANDIC FRINGE DIALECTS

Jørgen Rischel

Abstract: This paper deals with a phenomenon characteristic of certain regional varieties of Greenlandic Eskimo, viz. the so-called "i-dialect" in which /i/ has replaced /u/ in a great many instances. It is shown that this vowel shift is due to distant assimilation, and the resultant pattern is referred to as a case of "asymmetric" vowel harmony. Various descriptive models accounting for this pattern, and their possible implications for hypotheses about internalized grammar, are discussed.

1. Introductory remarks on vowel harmony

To a very first approximation, vowel harmony (henceforth: VH) may be defined as some kind of principled agreement, with regard to phonetic quality, among the vowels of consecutive syllables. In languages with VH it may be so that consecutive syllables agree more or less (under conditions to be specified) with regard to the labial articulation and/or frontness-backness and/or degree of openness of their vowels (under this provisional definition "umlaut" is included in the category of VH, of course).

There are other, more or less related regularities which refer to consecutive syllables but affect features other than the above-mentioned ones; unlike VH these other regularities often imply that consecutive syllables should be dissimilar rather than similar. Examples are: sequential alternation of long and short vowels or syllables; sequential alternation of stressed and unstressed syllables. (There may even be a specific conditioning among different features in consecutive syllables, cf. the phenomenon referred to in Nordic philology as "vowel balance", i.e., an interrelation between the quantity of a stressed syllable and the vowel quality of a following, unstressed syllable.)

VH has received considerable attention in the phonological literature, because the descriptive problems posed by this phenomenon are crucial for virtually all major aspects of phonological theory. There are numerous important contributions both representing structural linguistic schools and the transformational-generative trend. The emphasis on the different aspects varies, of course.

It should be realized from the beginning that VH may be approached from different angles. It is a commonplace that one should not confuse diachronic and synchronic statements (although the terminology, in the case of "assimilatory" phenomena, may invite such a confusion), but even from a strictly synchronic angle there are different kinds of statements to be made about VH in a language.

On the one hand, one may perhaps observe that there are some formatives (morphemes) whose phonetic shapes alternate in terms of VH, i.e., depending upon the vowels of adjacent formatives. Turkish is generally quoted as a case in point (cf. the alternating shapes of the plural formative in <u>adam-lar</u> 'men', <u>türk-ler</u> 'Turks'). It is then an immediate task to search for, and state, a generalization about these alternations, and more specifically, to make statements according to which the choice of alternants in all possible types of environments can be predicted. I shall refer to a generalization of this kind as a GENERATIVE statement. (Note that the term, as used here, does <u>not</u> refer specifically to the transformational trend in linguistics: statements about automatic alternation in the morphophonemic component of a structural linguistic grammar may be equally "generative".) The essential property of such a regularity, if stated in rule form, is that it is <u>assimilatory</u>, e.g. of the type: "a suffix vowel assumes the same frontness-backness specification as the vowel of the immediately preceding syllable". In addition to this specification of the assimilatory mechanism the rule must, of course, be supplied with a definition of its domain (i.e., the kind of stretch within which the rule exerts its power, be it a noncompound wordform, a wordform regardless of its complexity, or possibly even more complex stretches). And finally, it should be well-defined how the rule applies to a form, e.g., whether it applies iteratively so that a suffix vowel undergoing VH can, in turn, condition the quality of a following suffix vowel. Needless to say, there is a certain trading relationship between the formulation of the rule itself and the formulation of its conditions for application (if the rule referred to above is found to apply iteratively, one must consider an alternative, viz. the possibility of modifying the rule so that it assimilates all non-initial vowels "simultaneously" to the initial vowel).

On the other hand, one may observe that wordforms in a given language obey a phonetic constraint of VH type, e.g., a constraint which may be formulated like this: "within a wordform all vowels must agree with respect to frontness-backness". Note that this is not necessarily a statement supported by observed cases of vowel alternation; the statement simply implies that there are no wordforms in the language which are at variance with the VH constraint: there may be forms such as ili, olu, but *ilu, *oli are not well-formed since they violate the constraint. I shall refer to a generalization providing this kind of information as a STRUCTURAL GENERALIZATION. (Note again that the terminology is not intended to refer to particular "schools"; no sensible approach to linguistic description can do without structural generalizations of some kind, and indeed, well-formedness conditions are fully recognized in recent transformational-generative work, although there has been some uncertainty as to how such statements should be fitted into the total phonological description.)

It is important to note that generative VH rules, and structural generalizations about VH, may or may not coexist with the same domain of applicability in a given language. Like other assimilatory phenomena, vowel alternation conditioned by VH may well occur in connection with the affixation of one formative to another, even if there are formatives whose internal structure violates a strict VH constraint. This situation may be found in VH languages with a stratum of loanwords. Obviously, it may be so that the internal structure of some loanwords violates an otherwise existing VH constraint (Turkish may be quoted again, cf. otobüs 'bus' without internal VH, but plural otobüsler with VH between base and suffix). However, it is also possible for loanwords to be accomodated in terms of a mechanism of VH which is not otherwise found in the language. I shall illustrate this from West Greenlandic.

As mentioned briefly in Rischel 1974 (p. 459), Dano-Norwegian loanwords which are of some age in West Greenlandic have been modified so that they are (more or less) congruent with the well-formedness conditions of the "genuine" vocabulary. In this process of accomodation, VH comes in under three different kinds of conditions. Firstly, since the language has only three vowel phonemes, /a, ı, u/, each vowel shade in a foreign word must be allocated to one of these (and replaced by an appropriate allophone), but this leaves the neutral, unstressed vowel (schwa) unaccounted for. With some exceptions the indeterminacy has been solved by choosing a vowel exhibiting VH with a neighbouring syllable, example: Jørgen → /juulut/ or /juurut/ (ø is replaced by its nearest equivalent, viz. the long rounded back vowel /uu/, and the value of the final vowel is chosen accordingly). Secondly, initial consonants in foreign words which do not occur in Greenlandic words, are often made non-initial by adding a vowel in accordance with a VH rule, example: Jørgen → /ujuulut/ (old variant form from southernmost West Greenlandic). And thirdly, if impermissible consonant clusters are eliminated by the insertion of vowels, the quality of each epenthetic vowel is determined by VH. Examples are legion, e.g. blæk (blekk) → /pilikki/ 'ink' (the final /i/ is not interesting in this context; it will appear from the following examples that loanwords ending in a consonant are often augmented with a final /i/); trumf → /turuffi/ 'trump'; Knud (Knut) → /kunuut/, æble → /iipili/ 'apple'. - There is also a component of VH in the treatment of loanwords such as rør → /ruujuri/ 'tube', wire → /vaajari/.

It is probably clear from these few examples that VH plays a prominent role in the accomodation of loanwords in Greenlandic Eskimo. At the same time, there is no well-formedness constraint according to which consecutive vowels must exhibit VH: existing full vowels in loanwords are replaced by the nearest equivalent regardless of VH; hence kartoffel → /katurfili/ 'potato'; Efraim → /iikaliimi/ (southernmost West Greenlandic[1]), where there is no vowel insertion since the desired accomodation is obtained by metathesis. This does not mean that it is satisfactory to characterize the application of VH as "sporadic". Rather, it must be stated that VH in this context is a mechanism providing underspecified vowels with a full specification, or, in a different format of description, a mechanism that determines a unique representation for a variable. It is not a mechanism that changes one possible type of vowel into another possible type of vowel. Vowels that already have a fully determinate - and possible - representation, remain unaffected. But the mechanism of VH is no less regular for that reason.

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1) This dialect has /k/ or /q/ (depending on the environments) as the counterpart to general West Greenlandic /f/.

Somebody might claim that this kind of regularity is of peripheral importance for the phonology of a language: it is not part of the functional phonology per se but only an accomodation device that comes into force in the process of borrowing. In support of this claim one might mention that vowel epenthesis without VH seems to exist as a rule of the language, cf. the variant shapes of the relative case ending in /nuna+p/ versus /aqq+up/ and of the plural ending in /nuna+t/ versus /aqq+it/ (/nuna/ 'country'; /a¢iq/ ~ /aqq/ 'name'). If one chooses to speak of epenthesis here (see extensive data and discussion in Rischel 1974, Part II, § 2), the quality of the epenthetic vowel is determined by the following consonant, not by any vowel in an adjacent syllable. These two sets of findings need not be in descriptive conflict, however; one may claim that the VH mechanism taking care of loanwords is a kind of "morpheme structure rule": it has the single formative as its domain, and hence the suffix vowels of /Vp/, /Vt/ canot be affected by it. However, it is different if the vowel-zero alternation in the base of /a¢iq/ ~ /aqq/ (previously /atəq/ ~ /atq/) is accounted for in terms of epenthesis. In complex forms this base (and other bases of analogous structure) occurs with or without its second vowel, depending on the structure of the suffixes or suffix clusters; when occurring alone it is obligatorily bisyllabic in accordance with a well-formedness constraint prohibiting word final consonant clusters. If this second vowel is epenthetic, the existence of a VH rule would require that it came out as /a/, i.e. */ataq/ rather than /a¢iq/ (/t/ and /¢/ regularly alternate according to the quality of the following vowel). However, the vocalic reflex of this alternating set is invariably /i/ (similarly /tupiq/ 'tent', relative case /tuqqup/, plural /tuqqit/, does not occur in the shape */tupuq/).

Under these circumstances I should certainly not like to dismiss the loanword data as being of peripheral importance.

On the contrary, these forms, if anything, provide us with hard facts about mechanisms employed at the time of borrowing. It is, on the other hand, a matter of descriptive principles, and of more or less intimate knowledge of the pertinent data, whether one chooses to describe the vowel-zero alternation in /a¢iq/ ~ /aqq/ in terms of epenthesis, syncope, or straightforward alternation between two representatives of a category defined underlyingly by alternation. I have found, on quite independent grounds, that the synchronic data are not in favour of an epenthesis solution for /a¢iq/~/aqq/, /tupiq/~/tuqq/ (see Rischel 1974, ibid.), but I am at variance on this point with some phonologists writing about West Greenlandic. Anyway, I think the attested existence of a VH "blank-filling" rule for loanwords should cast grave doubts upon the validity of an epenthesis solution for the other bi- or polysyllabic bases.

I have stated that generative rules of VH may, or may not, be matched by well-formedness constraints, and vice versa. In fact, situations in which there is some kind of "mismatch", are more interesting than situations in which there is perfect coincidence: the former provide more information as to the internal structure of the languages in question.

There is a different angle to the question of how much information one can deduce from a set of generalizations about VH: "asymmetric" systems (see p. 9) give more information about the phonological make-up of the language than do "symmetric" systems.

If one faces a suffixational language in which every non-initial vowel exhibits strict VH with the preceding vowel (with regard to the features involved in the mechanism of VH for this particular language), there may be no more to be done about this than just stating the pattern of vowel alternation, e.g. "front vowel after front vowel, back vowel after back vowel", or "rounded vowel after rounded vowel, unrounded vowel after unrounded vowel", or whatever simple or complex statement may be true for this particular language. There are, of course, different formats of description that may be employed. One may say that (a) only word initial vowels are specified underlyingly for the features involved in VH, whereas all non-initial vowels are underlyingly incompletely specified ("archi-vowels" or "Pro-vowels") and only receive their full specification by a VH rule, or one may say that (b) each non-initial vowel is a variable ranging over a variety of vowel qualities, the choice of one specific alternant (i.e., the exclusion of other alternants) in a particular type of environment being predictable from a well-formedness constraint (strict VH). Given the VH data alone, it does not seem permissible to build more pattern into the description. Several phonologists prefer to elevate one of the alternants to the status of unique underlying representation and thereby introduce a directionality in the rule schema (e.g., one may postulate that suffix vowels are underlyingly all back but become front after front vowels). From the point of view of immanent description (description of patterning that is _in_ the language) this solution distorts the picture, however (a solution working with underlying front vowels and a rule according to which vowels are retracted after back vowels, might serve the purpose equally well, and hence the directionality is spurious).

There may be external criteria for making such a choice, e.g., the analyst may believe in some theory about universal markedness according to which one or the other alternant is more natural and "hence" the more basic one, but this is something different from statements about regularities inherent in the language under study. No matter how one approaches linguistics, it seems to me legitimate to require that the two kinds of criteria be kept distinct from one another.

Now, what is an asymmetric system, and why does it provide more phonological information compared to a symmetric system?

The phonological literature contains reports about languages in which most vowels participate in a system of VH although some vowels (possibly just one) behave differently. It may be that these latter vowels are totally excepted from undergoing VH, or totally excepted from conditioning VH in adjacent syllables, or it may be that they participate (one way or another) in VH when occurring in some formatives but not when occurring in other formatives. Such a situation is interesting, both for the theory of VH rules and for the theory of underlying representations. There are well-known instances of _umlaut_ that are just like this. For example, u-umlaut before a surfacing _u_ (modern [Y])in Icelandic has regular exceptions, cf. the stem _dag-_ 'day' in nominative singular _dagur_ versus dative plural _dögum_. It is a well-known argument that the reason why some occurrences of _u_ fail to produce umlaut, is that these are epenthetic (_dagur_ from _dag-r_ as against _sögur_, plural of _saga_ 'story', whose _u_ is not epenthetic). The connection between epenthesis and failure to produce umlaut can, in turn, be accounted for in terms of rule ordering: umlaut precedes epenthesis, or at least umlaut precedes the mechanism by which the epenthesis vowel gets a specification identical with that of umlauting _u_ (this may be read as a diachronic interpretation or, if one believes in synchronically ordered rules, as a synchronic description).

By asymmetry I refer to a particularly conspicuous type of skewness, viz. the situation in which it is true that X $\rightarrow$ Y next to a syllable whose vowel shares the differential features with Y, but _not_ that Y $\rightarrow$ X next to a syllable whose vowel shares the differential features with X. Icelandic u-umlaut may again serve as an illustration: _a_ goes to _ö_ before _u_, but it is probably generally assumed that it is inadequate to posit a rule with the opposite polarity, i.e. switching _ö_ to _a_ before non-_u_. If this contention is beyond discussion, it is tantamount to stating that there is an interesting determinacy in the underlying representation: instances of alternation between a and ö should all be derived from underlying a (not from underlying ö or from something in between). It is definitely of interest to distinguish such an (alleged) asymmetric mechanism from the kind of symmetry observable in Turkish VH, rather than concealing the difference by introducing a spurious directionality in the description of the latter. A careful distinction between the two kinds of pattern is useful also in a diachronic perspective: it may be that a pattern which is now perfectly symmetric originated as an asymmetric one (e.g., that suffix vowels whose underlying status is now indeterminate, used to behave asymmetrically so that one might speak of a unique underlying representation at an earlier stage). It should be possible, within the format of description chosen, to state the transition from one situation to the other.

To be honest, I do not consider it all that evident that the a-ö alternation in Icelandic is synchronically a matter of a unidirectional rule. Under that analysis, forms in which the alternant ö occurs in a word final syllable, must be accounted for by positing underlying w or u which vanishes (is deleted by some rule) after producing umlaut, but how can it be proved that this is always the appropriate solution? What prevents us from positing underlying ö in some instances and making the rule work both ways, so that ö is switched to a before a vowel that is not u? e.g. in röð 'row', genitive raðar? The argument runs, of course, that there are (always?) related wordforms whose vocalism is best accounted for in terms of underlying a, but what is meant by "related" in this context? Forms that are related historically may not have the same underlying vowel from the point of view of synchronic analysis, and what about paradigms such as gata 'street' -(oblique case) götu, for which related forms provide no cue (as far as I can see)? The very question whether a goes to ö, or ö goes to a here, may be an artefact of the descriptive approach (as for possible appeals to "psychological reality", I see no reason whatsoever to assume that either of the two proposals is true in that sense - maybe speakers simply master the paradigm as an alternation set; if so, an analysis claiming to reflect something psychologically real can, at most, define the vocalic entity in question as a category of alternants, not as underlying a or ö).

It is no real complication of the description to make the umlaut rule work both ways; on the contrary, it becomes a more generalized type of assimilatory mechanism. The important thing is to find unmistakable evidence for or against a symmetric conception of the pattern. - Again, it is interesting to trace the diachronic development, which obviously supports the asymmetric solution (underlying a), but the process by which u-umlaut came into existence should not be aprioricallly assumed to continue its existence as such. The synchronic data may not be unanimously in favour of such a description.

I think it is typologically worth while to search for VH patterns which provide unmistakable descriptive evidence (not necessarily psychological evidence)[1] for an asymmetric solution. The vowel harmony pattern of Greenlandic fringe dialects which is called "i-dialect" (see section 2.2), is a typical case, and that is one reason why I shall give a brief description of it below. Another reason is that the nature of this pattern, and in fact the very existence of a strict pattern, has not been stated in the literature on Greenlandic, the phenomenon being generally taken to be a matter of unconditional sound substitution (with inexplicable exceptions). There is thus a straightforward task of linguistic documentation to be taken care of.

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1) The term "descriptive" as used in this paper simply means "stating generalizations emerging from a study of the data". I must emphasize that it is not intended to mean "allegedly internalized".

2. The concept of "i-dialect"

2.1 Dialects of Greenland

Before entering into a discussion of "i-dialect" it may be expedient to give a brief survey of the major dialect divisions in Greenland.

The most obvious grouping of dialects is indicated by Roman figures in Fig. 1 (for details on dialect differences, see Petersen 1970). There are seven major groups of dialects, some of which are more homogeneous than others. "I" is Polar Eskimo, which is totally outside the scope of this paper. "II" is the Upernavik dialect, which exhibits the peculiarity referred to as "i-dialect". "III" is the group of dialects (differing but little from one another) spoken in the Uummannaq district and all along the Disko Bay. "IV" is the group of dialects spoken from Sisimiut (Holsteinsborg) in the North through Maniitsoq (Sukkertoppen) and Nuuk (Godthåb) and with several isoglosses North and South of Paamiut (Frederikshåb) providing a fuzzy boundary toward the next dialect group. "Standard" West Greenlandic is based on the dialects of group IV, which I shall refer to as Central West Greenlandic (CWG). "V" is southern West Greenlandic, as spoken in different varieties from Paamiut (Frederikshåb) and southwards to Nanortalik (as mentioned above, Paamiut belongs to the former group in some respects). "VI" is the Kap Farvel (Cape Farewell) dialect, as spoken at the southernmost settlements (my material is from Narsaq kujalleq = Frederiksdal). Finally, "VII" is East Greenlandic spoken at and around the towns Ammassalik and Scoresbysund. Dialects II, V, VI, VII all share the peculiarity referred to as "i-dialect". Thus, "i-dialect" is encountered in the northernmost (Upernavik) and southernmost parts of West Greenland as well as East Greenland, i.e., viewed from the geographical center in West Greenland, "i-dialect" is a characteristic of the fringe dialects (with the exception of Polar Eskimo, which entirely breaks off the dialect geographical continuity of the rest of Greenland).

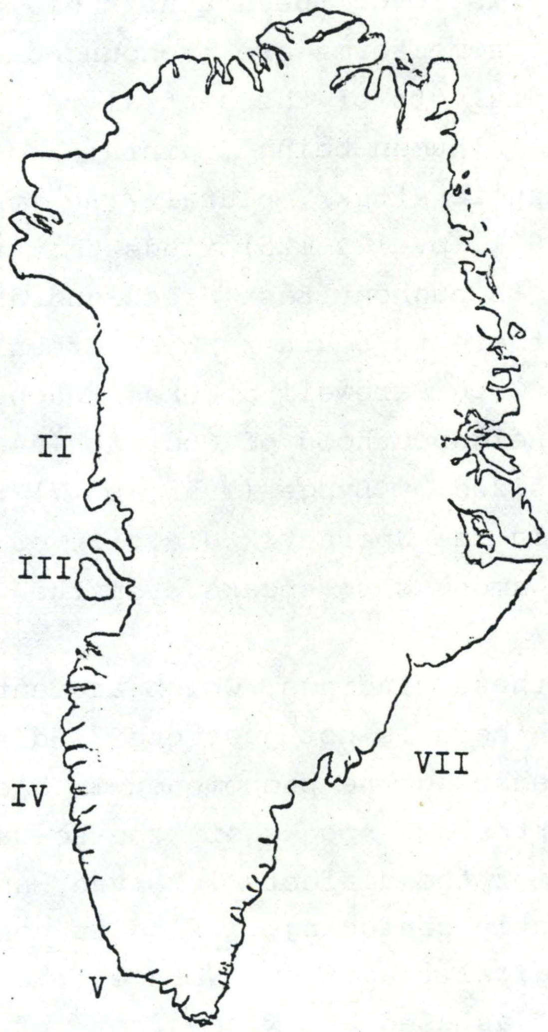

Fig. 1

2.2 What is currently meant by "i-dialect"?

In Schultz-Lorentzen's Greenlandic dictionary (1927) the entry "ersangavoq" is translated by "speaks dialect; speaks with the Southland accent; speaks the I-dialect".

This word, which is derived from ersappoq 'shows his teeth', refers to a characteristic of the southern dialects of West Greenland, viz. that some forms are pronounced with /i/ as against /u/ in the dialects of the central region of West Greenland, example: /inik/ 'human being', plural /ini^{v}it/ as against Central West Greenlandic /inuk/, plural /inu^{w}it/.

Thalbitzer (1921, p. 124-125) finds that this use of i instead of u occurs throughout East Greenland and assumes that it has spread from there to southern West Greenland: "This tendency has gone round Cape Farewell and has reached all the way up to the southern neighbourhood of Godthåb (64^{o} N. lat.)". - Later, it was emphasized by Lynge (1955, p. 7) that i instead of u is also dominant in the Upernavik district of northern West Greenland (and also among some speakers in the vicinity of the capital Godthåb).

According to these findings, which are entirely supported by linguistic data, there is not just one "i-dialect", but a number of dialects sharing the phenomenon in question. Petersen (1970, p. 331) nevertheless speaks of "the so-called "i-dialect"" in referring to all of the dialects involved, and although this terminology is slightly confusing, I find it convenient to continue the terminological tradition. Hence, the term "i-dialect" (in quotation marks) as used below does not refer to a dialect but rather to a phonological characteristic common to a number of dialects.

The comparative and diachronic aspects are immediately interesting. As for the question whether /u/ has changed into /i/ (in "i-dialect"), or /i/ has changed into /u/ (outside "i-dialect"), comparative evidence is entirely in favour of the former assumption, since Eskimo dialects outside Greenland (as well as Polar Eskimo) have /u/ not /i/ in these instances. Moreover, "i-dialect" entails a phonological merger of /u/ and /i/ (to the extent that /i/ is used instead of /u/), cf. "i-dialect" /inik/ 'human being', /sinik/ 'sleep' versus non-"i-dialect" /inuk/, /sinik/. Thalbitzer (1921, p. 124-125) also takes this position without any hesitation: "i ... has superseded u in a great many words and suffixes ... The change is limited to certain words while others have retained their u unmolested ...". Nonetheless, Lynge (1955, p. 7) contends that "the genuine Greenlandic i, which had been replaced by u in the further development of the language at other settlements, is still dominant up here [i.e. in the Upernavik district]" (translation mine). Although this view of the matter seems untenable in a comparative framework, there is some truth in it as far as the recent development is concerned, since non-"i-dialect" is now gaining ground, i.e., /u/ is being increasingly used in areas which are traditionally "i-dialect" areas (this process, which is promoted by the use of non-"i-dialect" in broadcasting and at school, is quite a slow one, however).

It is not the purpose of this paper to discuss the possible reasons why the phenomenon of "i-dialect" is shared by areas that are widely separated geographically, viz. Upernavik (II), East Greenland (VII), and southern West Greenland (VI, V, sporadically even IV). At all events, the dialect-geographical evidence strongly suggests that the origin of "i-dialect" must be of considerable age, but it cannot be decided easily whether inhabitants of different parts of Greenland successively took over the feature of "i-dialect" from their neighbours, or whether settlers at different places brought this linguistic feature with them in the first place (the former proposal is Thalbitzer's, as far as I understand him; the latter seems to be in agreement with Lynge). The present lack of a geographical continuity between the "i-dialect" areas may seem to suggest that these are relic areas, or offsprings from a common source which one might call "Proto-Fringe-Greenlandic". However, there used to be Eskimo settlements both in northern East Greenland and (more recently) in the southernmost part of East Greenland, so there may have been more linguistic continuity all the way round from Upernavik via East Greenland to southern West Greenland at an earlier time. A priori, this makes the "Wellentheorie" equally plausible. I shall leave the question at that here.

Now, to return to a characterization of the phenomenon of "i-dialect", it may not be exactly correct to say that /u/ just changes into /i/. An /i/ that stems from /u/ is sometimes accompanied by labialization of a following consonant, and if it is followed by /i/ or /a/, the vowel sequence is invariably reflected as /i/ plus a labial glide plus the second vowel (/ini^{v}it/ for /inu^{w}it/, etc.). The long (homosyllabic) vowel /uu/ changes into /ii/ (i.e. <u>not</u> /i^{v}i/, or the like) with or without a following labial component as in the case of single /i/ from /u/. I have suggested (Rischel 1974, p. 113-114) that /u/ did not change directly into /i/ but rather into a diphthong /iu̯/ whose second member is sometimes reflected as a labial component, and sometimes lost. This is entirely hypothetical; the hard fact is that the labialization or labial glide sometimes betrays the origin of /i/ as a reflex of /u/ (another such criterion is the different pronunciation of /t/ before original and secondary /i/ in the Upernavik dialect, see Petersen 1970, p. 332).

The "embarassing" thing about "i-dialect" is that the sound shift in question has seemed so entirely unsystematic in character. Petersen (1970, p. 331-332), who just speaks of a tendency and who does not seem to assume that the sound shift is contextually conditioned, adds: "The "i-dialect's" tendency to change /u/ to /i/ is far from consistent or sustained. There are still a great many words which preserve the /u/. A comprehensive explanation of these omissions is lacking. One can ... point out a few causes which work independent of one another. The first is the danger of syncretism with frequently occurring words in analogous contexts. The second is apparent consideration for practical articulation in that /u/ is often preserved as a back vowel with back consonants /k/ and /q/."

3. My own investigation

3.1 Material

During a stay in southern West Greenland in the winter of 1974-75 I worked intensely on "i-dialect", my first purpose being to gather as much material as possible for later comparison with material to be gathered in the Upernavik district. Since the chances of defining conditions for the sound shift seemed poor, I had chosen to attack the problem from the point of view of "lexical diffusion". It seemed to me that if it were known whether or not the sound shift occurs in largely the same lexical items in different dialects, this might provide a clue as to the connection between these various representatives of "i-dialect".

Most of the time I worked at the Kap Farvel dialect (VI) in the village of Narsaq kujalleq (Frederiksdal); this was later supplemented by material from the Alluitsoq (Lichtenau) fjord, which is within the general southern dialect area (V). My recordings (mostly tapes; to a lesser extent direct phonetic transcriptions) consist partly of free narrative prose, and partly (mostly) of responses to questionnaires which I worked out during my stay. The present paper is based exclusively on the latter type of material (the free prose still awaits processing). This means that I am making statements about the forms that dialect speakers prefer to use when they are conscious about their own dialect. There is no doubt that this gives a more regular pattern than analyses of fluent speech might give. It is conspicuous that "i-dialect" speakers often fluctuate between /i/ and /u/, and I have the impression that the bias is in favour of /i/ in such cases as far as my questionnaire material is concerned.

During my work I gradually realized that the phenomenon of "i-dialect" is explicable in terms of phonological rules, and fortunately it was possible to design new, supplementary questionnaires every time a new generalization emerged from the data. Thus, there was ample opportunity to recheck the validity of my observations and of my provisional generalizations.

The following is a quite preliminary report which focuses on the patterns that are firmly established after a cursory inspection of my data. Several problems are left out of consideration here, since they must await not only a closer study of the present data but also a gathering of comparative material from other "i-dialect" areas. As far as these other areas are concerned, the very limited experience I have with phonetic material from the Upernavik district and from East Greenland, seems to me clearly indicative that the basic pattern - as outlined in the present report - is the same everywhere, but the validity of this contention remains to be proved.

In view of the sketchy character of this report I do not feel that it would be reasonable to give anything like a catalogue of my data here. Recorded forms are cited "anonymously". They are taken from Kap Farvel (VI) material, unless otherwise stated. As for the phonetic presentation I have chosen a broad phonetic (semi-phonemic) transcription of the type used in my monograph (Rischel 1974). The only innovation is that I use an exponent letter /^{v}/ to indicate the rather faintly articulated labial glide in forms such as /ini^{v}it/ 'human beings'.

3.2 Comparative generalizations to be made about "i-dialect" forms

Before attempting to establish phonological conditions for "i-dialect" forms it is reasonable to test one specific hypothesis, viz. that mutually related forms tend to have the same vowel (i.e. either /u/ throughout a set of related forms, or /i/ throughout). A tendency or regularity of this kind might seriously confuse the pattern. - Interestingly enough, a glance at the data immediately reveals that levelling of this kind plays no discernible role in the Kap Farvel dialect (on this point I dare not make any statements about other dialects). The verb for 'being shy' (CWG /ittuu^{r}ppuq/) is /it¢ii^{r}puq/ (previously undoubtedly /ittii^{r}ppuq/), but the participle (meaning 'shy') is /ittuu^{r}tuq/ (CWG /ittuu^{r}ttuq/), i.e., there is no avoidance of a vowel alternation in the second syllable of the base. Similarly, although the counterpart to CWG /inuuniq/ 'life' is /iniiniq/, the greeting /inuuLLu^{w}a^{r}nna/ 'goodbye' (literally 'live well!') is reflected as /inuuɖu^{w}a^{r}nna/.[1] The counterpart to CWG /iLLu/ 'house' is /iɖɖiq/, but the word for cottage ('wretched house') is /iɖɖurujuk/. These examples give further evidence of vowel alternation in the second syllable of a base.

An abundance of data of this kind entirely disproves the hypothesis that there might be a significant tendency toward invariance within sets of etymologically related forms. At the same time they testify to a phonological regularity in the Kap Farvel dialect, viz. that /u/ is (normally) preserved if followed by a non-labial consonant (cluster) plus /u/. - I shall return to this regularity below.

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1) /ɖ/ is the regular counterpart to /L/ of other West Greenlandic dialects (/ɖ/ is a retroflex affricate, as far as I have been able to ascertain; Petersen 1970 writes /dʒ/ but does not consider this symbol quite appropriate).

As mentioned above, Petersen (1970) suggests that neighbouring /k/ and /q/ may help to preserve /u/. It is easy to prove that this is at least not a strict constraint, cf. /inik/ for /inuk/ 'human being', /maanakkit/ for /maan(n)akkut/ 'now', /sikiq/ for /siku(q)/ 'ice', /¢ikiqqirippuq/ for /¢ikiqqurippuq/ 'is at right angles'. I do not see how one can formulate a constraint that permits all these forms.

It may prove useful to search for other constraints, however, i.e., to search for environments in which /u/ never changes to /i/. No matter how sporadic and irregular the sound shift may be, it would not be expected to violate constraints, and thus the formulation of constraints (rather than positive conditions for the sound shift) is a way of detecting whether there is at all anything like phonological regularities involved. It is not a priori clear what would be the appropriate domain of such constraints, but I decided tentatively to use a stretch corresponding to the typographical word (i.e. anything written without internal interspace) as a frame of reference. As it turned out, this domain, which can be redefined phonologically as a "phonological word" on the basis of prosodic characteristics (Rischel 1974, pp. 11 and 79), turned out to be a highly appropriate choice. - The most conspicuous constraints detected in this way will be listed (in random order) below. I shall stick to structural generalizations in this section, but in section 3.4 below I shall demonstrate how a study of phonological alternation adds significantly to an understanding of the nature of the constraints in question, both with regard to diachrony and synchrony.

(a) There is never /i/ against CWG /u/ in a word initial syllable: KF = CWG /s<u>u</u>li/ 'still', /<u>u</u>uma/ 'of that one', /n<u>u</u>taaq/ 'new', etc. etc.

(b) There is never /i/ against CWG /u/ if the vowel is immediately preceded by a consonant or consonant cluster with labial articulation: KF = CWG /ap<u>u</u>t/ 'snow', /imm<u>u</u>k/ 'milk'.

(c) There is never /i/ against CWG /u/ after a syllable with /u/. The preceding syllable may have /u/ because of constraint (a): KF = CWG /$\underline{u}$k$\underline{u}^{w}$a/ 'those', /$\underline{u}$nn$\underline{u}$k/ 'evening', or because of constraint (b): KF = CWG /imm$\underline{u}$ss$\underline{u}^{w}$aq/ 'cheese' (traditional CWG: /immuṣṣu^{w}aq/). But it may also be because of constraint (d) below, which considerably complicates the pattern:

(d) As mentioned earlier, there is a strong tendency to preserve /u/ if the following vowel is /u/ and there is no intervening labial consonant: KF = CWG /i^{r}nnis$\underline{u}$ttuq/ 'giving birth' (but with an intervening labial: KF /i^{r}nnis$\underline{i}$ppuq/ 'gives birth' against CWG /i^{r}nnisuppuq/; further examples in the beginning of this section). This is at first sight a rather crazy constraint: why should /u/ be protected before /u/ only if there is no intervening labial? One might suggest that there is an umlaut mechanism involved: /u/ has gone at least part of the way to /i/, but /u/ is restated due to influence from the vowel of the following syllable; however, the distant assimilation in terms of liprounding cannot work if the chain is broken by a labial segment.

Another explanation has been offered to me by Eli Fischer-Jørgensen (personal communication): in forms such as /i^{r}nnisuttuq/ the consonantal stretch /tt/ was probably influenced by preceding and following /u/ and hence spoken with liprounding; it therefore protected the preceding vowel from going to /i/. The labial /pp/, on the other hand, would not show any clear difference between rounded and unrounded varieties, and hence did not give similar information regarding the preceding vowel. Therefore, /u/ was not protected before labial plus /u/. - This is a very interesting possibility; I entirely agree that there must have been labialization of consonants in some environments (see below), and that this feature was probably masked in labial consonants. However, there is a seeming conflict in that - as far as the evidence at my disposal goes - such secondary articulation in consonants is preserved more in the dialects that make the least use of constraint (d). As long as there is insufficient information especially with regard to the Upernavik dialect, I dare not argue about this, however.

I think it is plausible enough that there used to be a shift of /u/ (either all the way to /i/ or to something that would eventually end up as /i/) also in these environments. This is in fact attested in other representatives of "i-dialect": I have noted forms such as /sikikkut/ e.g. from the Upernavik district against CWG and KF /sikukkut/ 'via the ice'. But the reestablishment (or preservation) of /u/ in the southernmost dialects may be a protective measure. If the first of two consecutive syllables with /u/ changes its vowel into /i/, one of two things may happen: the vowel shift may reapply and shift /u/ of the next syllable since it is no longer preceded by /u/ (in an alternative analysis: the vowel shift may apply simultaneous to both syllables), or the vowel shift may not be allowed to reapply. Apparently the Upernavik and East Greenland dialects are characterized by prohibiting a reapplication, whereas the southernmost dialects favour a uniform treatment of both syllables.

In the case of two consecutive syllables with /u/ there is a very obvious prevalence of preservation of both vowels as /u/. I have nevertheless noted some instances where both vowels are shifted. Thus, one of my KF informants insisted that one would say /kaagi^{r}tøi^{r}ɖɖita/ corresponding to CWG /kaagitu^{r}LLuta/ (/kaagi^{r}ttu^{r}LLuta/) 'we, eating cake', but I suppose that other persons might say /kaagi^{r}ttu^{r}ɖɖuta/. As for the Alluitsoq dialect (within area V of Fig. 1), a young informant of mine used such forms as /ma^{r}LLiLLiiniit piŋasiLLiiniit/ 'either two or three' (CWG /ma^{r}LLuLLuunniit piŋasuLLuunniit/), although he had a general prevalence of preserved /u/ in two consecutive syllables with etymological /u/. Now, this shifting of both vowels would lead to forms such as /sikikkit/ (which I have encountered as a variant of /sikukkut/), and similarly */i^{r}nnisitøiq/ instead of /i^{r}nnisuttuq/ (which I have heard only with /u..u/). Forms such as /i^{r}nnisuppuq/, on the other hand, could never get any further than /i^{r}nnis<u>i</u>ppuq/ since the following /u/ is protected anyway by the labial consonant (constraint (b)). Hence, if for some reason there was a reaction against such a drastic change as /i^{r}nnisuttuq/ to */i^{r}nnisittiq/, modern */i^{r}nnisit¢iq/, it would only be necessary to restate /u/ in cases where there was <u>no intervening labial</u>, since this is the only case in which two consecutive syllables can both undergo the vowel-shift.

For the sake of completeness I shall add that /u/ may be preserved by constraint (d) in more than two consecutive syllables. Thus the KF form corresponding to CWG /niiqquluttuq/ 'creaking' is /niiq<u>u</u>l<u>u</u>tt<u>u</u>q/, as expected.

It is interesting to note that paradigmatic levelling plays <u>no</u> role in the treatment of /u/ before /C_1u/; on the contrary, the occurrence of /u/ here often creates an alternation, because the vowel is shifted in other forms. This fact might perhaps speak in favour of the umlaut interpretation since umlaut is known from other languages to produce alternation, whereas one might perhaps expect a protective mechanism to preserve, rather than break down, a conspicuous relatedness among wordforms. That is hardly conclusive, however.

Constraints (a) through (d), if properly applied (see below) appear to account for the vast majority of forms that are consistently spoken with /u/, not /i/. There is, nevertheless, a residue of bases, suffixes, and complex stems which defy any explanation in terms of a phonological generalization. One may attempt to define certain <u>tendencies</u> to preserve /u/ under specific circumstances, and indeed, some of the forms with unexpected /u/ agree with Petersen's suggestions (1970, p. 332), which I cited above. The allative ending /nut/, for instance, has /u/ in southern WG, and it is natural to assume that this is due to the need of avoiding a merger of allative /nut/ and ablative /nit/.

(East Greenlandic permits the vowel shift in allative -<u>nun</u>, -<u>nin</u>, according to Thalbitzer 1921, p. 133; note that the ablative forms have been replaced by instrumental forms in this dialect.)

As for Petersen's contention that /u/ is often preserved in the context of back consonants, there are quite a few exceptions to the shift of /u/ to /i/ which may have this explanation, viz. forms with a uvular plus /u/, e.g. the suffix /qu/ 'command' (KF /qaaqu^{w}aa/ 'invites him'), and the suffix alternant /ru/ 'future time' (KF /aasaru/ 'next summer') as against /ŋi/ (from /gu/) 'id.' (KF /aqaŋi/ 'tomorrow').

But as mentioned earlier, these are not real constraints since it is easy to find counter-evidence. Moreover, there is a residue of unexpected occurrences of /u/ anyway, often so that a formative may occur in some lexicalized forms with /u/ and in other forms with /i/ although there is (according to my statements) no relevant difference in the phonological environments, cf. /piluk/ 'bad' in KF /naasupil<u>u</u>^{w}it/ 'weeds' versus /uqalipil<u>i</u>ppuq/ 'scolds'. - A study of Thalbitzer's (1921) texts from East Greenland even shows a certain amount of <u>free variation</u> between /u/ and /i/, e.g. in forms containing the stems /taku/∼/taki/ 'see', /isuma/∼/isima/ 'thought; think' before invariant suffix configurations. I have no explanation of this. In the Kap Farvel dialect the norm of elderly and middle-aged persons did not seem to waver very much, whereas there was a discernible difference between the norms of different generations, as one might expect.

I have tried to show that the general picture is not just fuzzy, not even in East Greenlandic. It is significant that the exceptions to the generalizations are <u>forms in which /u/ is unexpectedly retained</u> rather than forms in which /u/ is unexpectedly shifted to /i/.

In the following I shall neglect the exceptions, since there is such a massive bulk of evidence in favour of the linguistic significance of the regularities.

Constraints (a)-(d) above are not well-formedness conditions on phonetic forms. It is perfectly possible to have /i/ in all of the environments in question if only this /i/ does not reflect /u/ diachronically, cf. the underlined vowels of /imiq/ 'water', /usii/ 'its cargo', /ilumut/ 'certainly'. The constraints only define the conditions under which /u/ cannot go to /i/.

Now, it is interesting both from the point of view of diachrony (relative chronology of sound-shifts) and from the point of view of synchronic analysis to know whether these constraints are properly stated in terms of surface structure, i.e., whether the segments entering the prohibiting contexts are always surfacing. There is no doubt that this was the case at the time when the pattern came into existence, but is it correct to formulate these constraints with reference to the surface structure of modern Greenlandic? It is possible to throw light upon this question by studying forms in which the relevant segments in the context of /u/ have undergone assimilation.

In most dialects of Greenland the diphthongs /ai/ and /au/ have been entirely assimilated to /aa/ word internally (Rischel 1974, p. 73 ff). Now, what is the fate of /auC_1u/ in "i-dialect": is it reflected as /aaC_1u/ or /aaC_1i/? My material suggests that there is a good deal of vacillation here. At any rate, there are examples enough of preserved /u/ to make it entirely implausible that these are random exceptions to the general pattern: /nauṣut/ 'flowers' is reflected as KF /naasut/; /auk+luunniit/ 'or blood' is reflected as KF /aaɖuuniit/; etc.

As for /u/ preceded by a labial consonant or consonant cluster, it is worth while examining what happens if the cluster consists of a labial plus another consonant since there is regressive assimilation here (Rischel 1974, p. 34 ff). In this case there is overwhelming evidence in favour of a constraint to the effect that /u/ is preserved after a labial even if the labial is eventually assimilated: /aaŋŋuuq/ 'yes, it is said' (obviously containing /aap/ or /aam/ 'yes') is reflected as KF /aaŋuuq/; ?/ani+wluni/ (CWG /aniLLuni/) 'going out' as KF /aniɖɖuni/; etc.

3.3 The vowel shift as distant assimilation

In the preceding section I have attempted to demonstrate that "i-dialect" is not a matter of "sporadic" replacement of /u/ by /i/. If the sound shift is assumed to occur without any language-internal, phonological conditioning it is nevertheless subject to systemic limitations. It is natural now to ask: do these limitations make sense? Is it "natural" that /u/ is preserved in such and such environments? If a sound-shift is subject to phonological conditioning (positive or negative), it is hopefully so that the conditions are either all explicable in terms of general phonetic mechanisms or all deducible from one general principle.

Constraints (b), (c), (d) may be referred to one common principle if rounded vowels and labial consonants are supposed to share a cover feature of labiality. The generalization, then, runs as follows: /u/ is protected if it is part of a segment sequence exhibiting labial harmony, viz. a sequence of the structure $[+\text{labial}]C_o[+\text{labial}]$. This is true, in <u>all</u> dialects, of a vowel that is non-initial in such a sequence (i.e. which occupies the position <u>after</u> /uC_o/ or after a labial consonant). If, however, /u/ is absolutely initial in the sequence (i.e. is followed but not preceded by a labial segment) the principle applies regularly only in the southern dialects, and only if the closest following labial segment is a vowel (see discussion of constraint (d) in section 3.2).

The fact that /u/ is not protected <u>before</u> a labial consonant (cluster) plus /u/ (/iʳnnis<u>i</u>ppuq/ in spite of /iʳnnis<u>u</u>ttuq/)

disturbs the otherwise neat principle of labial harmony. It makes diachronic sense, however, if the vowel-shift was initiated as a diphthongization, i.e. a delabialization of the initial part of /u/: under that interpretation it is nothing surprising that preceding and following labial consonants have had different effects.

Constraint (a) has no connection whatsoever with the other constraints. It is not very obvious why the position in an initial syllable should prohibit a change of vowel quality which occurs spontaneously in other syllables, unless the change in question were some kind of laxing (reduction), which clearly is not the case.

It must be concluded that the constraints formulated in section 3.2 are observationally adequate but fail to provide a simple and natural characterization of the phenomenon of "i-dialect" in terms of general phonetic theory.

The logical move, then, is to turn the whole thing around and work on the assumption that we do not have a spontaneous sound-shift which is subject to a number of constraints but rather a <u>conditioned</u> sound-shift. Can it be true that the change of /u/ to /i/ occurs only in one particular type of environment, and is in fact due to the influence of that type of environment?

If we look at the repertory of forms with /i/ for /u/, it is a true generalization that this vowel segment is preceded by a syllable with an unrounded vowel, and that there are no intervening labial consonants. Hence the sound-shift may be described as <u>assimilation to a preceding non-labial sequence of segments</u>. The vowel /u/ (perhaps first the initial part of the segment) is delabialized by assimilation to a preceding vowel /i/ or /a/ unless there is an intervening labial. From the phonetic point of view this is an entirely natural type of mechanism.

This description absorbs constraints (a), (b), (c) into one rule of assimilation but sets off constraint (d) from the rest. That is interesting since it is exactly constraint (d) that has a more limited distribution than the others. I think the assimilation hypothesis lends support to the assumption that constraint (d) is in fact a protective measure found in cases where /i/ from /u/ might serve as a new context for delabialization of a following /u/, i.e., where the assimilation might apply iteratively. Now, why would the southern dialects admit such iterative application rather than the Upernavik and East Greenlandic dialects? I think there is an answer to this. In the Upernavik area there is evidence (according to Lynge 1955 as well as my personal experience) of a sporadic retention of a labialization component in consonants that follow after an /u/ that has been shifted to /i/, e.g. something like /naakkaŋii^{w}q^{w}/ as the counterpart of CWG /naaxxaguuq/ 'no, it is said', and this phenomenon is also attested in Thalbitzer's East Greenlandic material (1921). Now, as long as such labialization is present it prohibits a following /u/ from shifting to /i/: if /sikukkut/ goes to /siki^{w}kk^{w}ut/ it is entirely regular for the last /u/ to be preserved since it is still preceded by a sequence containing labiality, and it is no wonder that such a form may be continued as /sikikkut/ with an eventual loss of labiality but no extension of the assimilation rule so that it would apply iteratively or across the board. In the southern dialects, on the other hand, there is no trace of such labialization: it may have vanished so early that the assimilation had not yet been stabilized as a mechanism operating just across one syllable boundary but no more. Hence the situation was stabilized by restoring /u/ according to the sequential constraint (d) so that the ultimate output was /sikukkut/ (or possibly /sikikkit/ if the assimilation was given a free run) rather than /sikikkut/. (Incidentally, the existence of a mechanism of restoration is corroborated by a number of forms in the southernmost dialects, in which etymological /i/ or /ï/ is shifted to /u/, e.g. /u^{w}aŋuttunni/ 'in us', as against CWG /u^{w}atɇinni/. There are some quite specific generalizations to be made about these "hypercorrect" forms, but they fall outside the scope of the present paper.)

3.4 Alternations created by the vowel-shift

I have mentioned several times that the KF dialect has numerous, and in fact regular, alternations between indicative and participle forms, the last syllable of the stem alternating between /u/ and /i/ if the conditions for delabialization are present: model example /i^{r}nnisippuq/ - /i^{r}nisuttuq/ as against /tuquppuq/ 'kills' - /tuquttuq/ with invariant /u/ (the preceding syllable has /u/) and /¢ikippuq/ 'arrives' - /¢ikit¢iq/ with invariant /i/ (the vowel was /i/, not /u/, in the first place). There are innumerable other instances of alternation due to constraint (d), cf. /inik/ 'human being' (from /inuk/) but /inurujuk/ 'giant' (suffix /rujuk/), also cf. the example /sikiq/ - /sikukkut/ mentioned earlier. Transparent suffixes may exhibit the same alternation due to the influence of a following suffix: /paami^{j}it/ (from /paami^{j}ut/ 'inhabitants /-miut/ of the mouth of the fjord /paa/') 'Frederikshåb' but /paami^{j}unuka^{r}ppuq/ 'travels to Frederikshåb'.

Suffixes also exhibit extensive alternation depending on the structure of the preceding stem, cf. the participle suffix /tuq/$\sim$/¢iq/ in /tuŋuju^{r}ttuq/ 'blue' versus /qi^{r}nni^{r}t¢iq/ 'black', /suŋaa^{r}¢iq/ 'yellow', or the suffix /suuq/$\sim$/siiq/ 'who has the quality (or: does so) to a high degree' in /pu^{r}ttusuuq/ 'high', versus /pu^{w}alasiiq/ 'fat'. This is not just a matter of lexicalized forms with one or the other vowel, since the same alternation occurs in suffixes that can occur after practically every conceivable wordform, cf. KF /ŋuuq/$\sim$/ŋiiq/ 'it is said (that)' in /nuŋuppuŋŋuuq/ 'they have been used up, it is said', /aani^{j}aruŋŋuuq/ (or /aaŋuŋŋuuq/) 'fetch it!, it is said' versus /tassaŋiiq/ 'that's enough!, it is said', /iki^{j}i^{r}ssinnaavaa¢iŋŋiiq/ 'he can help you, it is said'.

As a final example I shall quote the suffix /luunniit/ 'or', which occurs in the KF dialect in a variety of forms with /uu/ or /ii/, and with /l/ or /ɖ/ (depending on the preceding formative). If occurring in two consecutive forms (with the meaning 'either - or -'), it may or may not alternate depending on the last syllables of the forms to which the suffix is added, e.g. /ataasi^{r}ḍḍiiniit ma^{r}ḍḍuḍḍuuniit/ 'either one or two' (cf. the deviant forms in the Alluitsoq dialect cited in section 3.2 above); /puu^{r}luluuniit kaagi^{r}ḍḍiiniit/ 'either a ball or a cake'.

This shows that there is no general tendency to achieve an invariant manifestation of formatives as far as /i/ for /u/ is concerned. Examples like the last-mentioned ones are clearly reminiscent of the appearance of forms in languages with a functional system of vowel harmony (Thalbitzer 1921, p.124 did in fact notice a tendency toward VH in East Greenlandic, but he speaks of it as a quite sporadic phenomenon found with some suffixes).

4. Problems in a synchronic, generative description of "i-dialect"

In the preceding sections I have shown that (i) the sound-shift initiating the phenomenon known as "i-dialect", was rule governed, and (ii) this sound-shift has implemented a rather regular pattern of vowel alternation. The question, now, is how to deal synchronically with the behaviour of vowels in dialects of this type. For simplicity I shall start with the question of synchronic rule, and approach the question of underlying representation afterwards.

4.1 Is there a synchronic rule?

Generative phonologists have always taken much interest in alternations because these were taken as evidence for phonological rules. There has been a tendency to go very far in the claim that alternations reflect synchronic rules, but recently there has been an increasing degree of scepticism toward an indiscriminate use of rule schemata in linguistic description. This scepticism is an offspring of a desire to make the description reflect something <u>real</u>, in particular: some kind of <u>psychological</u> reality. Unfortunately, the meaning of this term in modern linguistic literature is quite vague, and there has not been too much progress so far toward a real understanding of the nature of the problem.

Even a description that does not claim to be psychologically "real", may be subject to evaluation in terms of plausibility. We do not know what goes on in individual speaker-listeners' heads, nor do we know what mental patterns are common to users of particular language, and one may argue that linguists have no obligation to describe just that. But it must certainly be worth while trying to distinguish <u>regularities which may be relevant to the way in which users of the language master it</u>, from other possible generalizations, which are likely to be irrelevant from that point of view. One should, of course, be gravely suspicious toward rigid (and generally quite aprioric) "psychological" interpretations to the effect that a certain regularity <u>is</u> a rule in the generative sense, but it seems fruitful to attempt to provide evidence for (or against) the contention that speaker-listeners are likely to internalize a mechanism that is functionally equivalent to such a rule. To provide, or evaluate, such evidence is no straightforward task, however.

In the case of a pattern of alternation it is an oversimplification of the problem just to ask: is the regularity likely to be mastered by rule? There are at least three meaningful proposals: (i) all the forms involved may be individually stored (lexicalized in a strict sense); (ii) there is an awareness of mutual relatedness among partially similar forms, and the recurrent patterns of alternation within paradigms are mastered so that they can be used productively; (iii) there is some kind of analysis of wordforms into building-blocks (more or less co-extensive with the linguist's formatives), each of which is stored mentally together with information about its own pattern of alternation as well as its conditioning effect on alternations in adjacent items. - In all likelihood there is normally a good deal of redundancy in the mental representation; there is no reason why a speaker-listener should not store several inflected or derived forms containing the same base (solution (i)) although some of them may be deducible from the others according to patterns mastered by him (solution (ii) or (iii)). We do not know, in principle, <u>what</u> is stored mentally, although studies on productivity (as suggested by Ohala) may provide some information.

The formulation and testing of such proposals (and of other, more or less similar proposals that one might find worth formulating) has not much to do with the current, transformation-generative paradigm of linguistic description (although it is a merit of recent work to have emphasized the importance of the question of internalized representation of linguistic patterns). I do not think that one should start by asking: "is there, or isn't there, an internalized equivalent to the schema X $\rightarrow$ Y /W__Z" (meaning: representation X is <u>replaced</u> by representation Y in environment W__Z); it must be determined first to what extent an alternation is at all mastered in terms of generalized mechanisms. That, in itself, is certainly a difficult issue.

With regard to "i-dialect", the null-hypothesis, i.e., that all wordforms exhibiting some reflex of etymological /u/ are completely lexicalized (stored in their entirety in the brain), can be dismissed without serious testing. Eskimo is a "polysynthetic" language, which in principle allows for an unlimited number of different wordforms to be construed by suffixation to one common base. The unlimited character of suffixation is proved by the fact that a suffix may even recur in such a stretch, each time restoring the same conditions for further suffixation, e.g., a noun stem may be converted into a verb stem by suffixation of /u/ ('to be'), and the resultant verb stem (with more or less elaboration by other suffixes) may in turn be converted into a noun stem by suffixation of /ṣu(q)/ ('one who -s'), so that the conditions for forming a verb by suffixation of /u/ ('to be') once again are met. (Maybe such repeated use of a suffix occurs chiefly if part of the sequence is lexicalized with a specific meaning, e.g. /iga+ṣuq/ 'one who cooks' has a lexicalized counterpart /igaṣuq/ 'cook' from which one may form /igaṣu+u+ṣuq/ 'one who is a cook'. However, it is worth noting that the relatedness of /igaṣuq/ to /iga/ and /ṣuq/ is transparent enough.) - Given the considerable number of different suffixes, and the enormous number of consecutive suffixes that one may often identify in Greenlandic wordforms, it is a priori clear that speakers and listeners cannot do with a stored inventory of wordforms (this is not in the first place a matter of assumptions about limited storage capacity in the brain; the core of the problem is that it cannot possibly be true that every fluent speaker-listener has previously encountered all grammatically possible wordforms). Anyway, the general lexicalization hypothesis can be easily disproved by the fact that one can take international (Danish) terms and add Greenlandic suffixes to them (often with little or no accomodation of the stem to Greenlandic phonotcatics). Stems such as <u>trillebøri</u> 'wheelbarrow', <u>præsidenti</u> 'president' are entering the language all the time, and such a base may be elaborated by suffixation at one's discretion. In oral or written communication such hybrid forms will normally be immediately understood. The interesting thing is that the principles according to which suffixes are added after each other in such forms, are entirely Greenlandic. It is only the base that constitutes a chunk of foreign matter.

In principle, the inventory of forms is *an open inventory whose size canot be defined*. This is true both of entire *word-forms* and of invariant *stems* (understood as the part of a word-form - however elaborate - that is invariant in an inflectional paradigm).

There is a different proposal, however, that might be more worthy of serious consideration, viz. that *dyads of formatives* are stored lexically. If, for a moment, we disregard loanwords and other foreignisms and consider the inventory of bases as a closed inventory, it is certainly possible to set up a model according to which every conceivable sequence of two formatives (or of formative clusters in some instances)[1] is lexicalized. The number of such dyads will be very large, of course, but not unlimited, and hence it cannot be disproved a priori that word-forms containing bases which are already well-established in the language, are mastered with reference to such dyads.

Under such a hypothesis the conversion of content into expression - in generative-semantic terms: the lexical insertion - would be a complex matter. Each constituent of a word-form must be looked up in the internalized lexicon twice: it must be checked whether it has an entry together with the preceding constituent, and whether it has an entry together with the following constituent (unless, of course, the constituent in question is word initial or final, in which case there is only one dyad involved). Hence, if the KF form /muluɖɖuni/ 'as he stayed away longer than expected' (/mulu/ 'stay away etc.', /ɖɖu/ 'contemporative mood', /ni/ 'he himself') does not happen to be stored in its entirety, it must be looked up as /muluɖɖu/ and /ɖɖuni/. There must then be some strategy according to which such consecutive dyads are amalgamated. This strategy is

1) The concept of "formative dyad" raises the same question as to psychological reality (e.g. of grammatical boundaries) as the concept of "formative" itself (in addition to the implausibility caused by the syntactically dubious status of the dyad).

simple if it is just a matter of shrinking material of the type XY, YZ into XYZ (as in /muluɖɖuni/), but what if there is an alternation in the shared part? The dyad consisting of 'contemporative' plus 'himself' must have a variant /ɖɖini/ since 'as he slept' is /siniɖɖini/, composed of /siniɖɖi/ and /ɖɖini/. Apparently there must be a <u>rule</u> saying: choose the alternant, in each case, that gives no conflict between the phonological representations of two dyads to be amalgamated. This solution is probably sufficient for dialects that adhere strictly to constraint (d) of section 3.2: assume that 'because I ate meat' is /niqi¢irama/; 'if I eat meat' is /niqituruma/; 'because I entered' is /isirama/; and 'if I enter' is /isirima/. We can, then, posit the following dyads: /niqi¢ir/∼/niqitur/ 'eat meat'; /¢ira/ 'because of eating'; /turu/ 'if eating'; /isira/ 'because of entering'; /isiri/ 'if entering'; /rama/ 'because I'; /ruma/∼/rima/ 'if I'. There will be only one possible output in each case on account of the principle of no conflict (whereas there would be two possible outputs for 'if I eat meat', viz. /niqituruma/ and /niqi¢irima/, if there were a variant /¢iri/ along with /turu/ 'if eating').

Dialects without constraint (d) pose no specific problems. The difference can be handled in terms of lexical representation of dyads: 'eat meat' is stored as /niqi¢ir/, 'if eating' is stored as /¢iru/ (/tiru/)∼/turu/. The principle of no conflict between dyads uniquely determines the output for 'if I eat meat' as /niqi¢iruma/ (/niqitiruma/).

Etymological /u/ is sometimes reflected "idiosyncratically" as /u/. Now, if the conditional mood formative does not ever occur as /ri/ (i.e., if we find /ru/ in environments where the general principles of "i-dialect" would suggest /ri/), the dyads containing this formative are simply not stored in a variant with /i/: we have /ruma/ 'if I' but no /rima/, /isiru/ 'if entering' but no /isiri/ for such a dialect, and hence the form meaning 'if I enter' comes out automatically as /isiruma/.

To a first approximation, then, phenomena such as the /u/ - /i/ alternation can be handled in terms of storage of dyad variants plus an entirely general principle of selection. Are there any principled arguments about such an approach to linguistic description?

If one believes that there is a level of linguistic description at which lexical items (or lexical entries) are grammatical constituents, a description in terms of formative dyads is not immediately attractive. Let us consider /niqituruma/ 'if I eat meat' from the point of view of internal structure. The first formative dyad, /niqitur/ 'to eat meat' is (according to my definition) a stem, and hence it makes perfect sense to speak of it as a grammatical constituent at a non-abstract level of syntactical description. The final dyad, /ruma/ 'if I do', may be looked upon as a cluster of inflectional material modifying the stem, and hence it also makes sense to speak of that as a constituent. But what about the middle one: /turu/ 'if eating'? It cannot be a constituent at the same time as the others. However, in semantically based syntax the formation of stems such as /niqitur/ may be interpreted as a kind of incorporation, the abstract constituents being 'meat' and 'eat'. In the framework of such an analysis there is nothing strange in claiming that the verb component 'eat' goes together with the modal modifier to form a surface constituent. We are thus faced with a possibility of conflicting analyses. There may be other types of forms in which it is much more difficult to find a reasonable correlation between formative dyads and possible grammatical constituents, but at least it should be realized that the whole issue is controversial. One cannot a priori dismiss the dyad approach on these premises (as long as it has not been proved that the internalized lexicon is accessible at only one level of syntactico-semantic abstraction).

Another possible argument against the dyad approach is that it is "clumsy". It entails a storage of numerous dyads in two or more variants instead of a phonological rule. In the framework of transformation-generative phonology one might also claim that it is not "insightful" because it fails to reveal the phonological mechanism involved. The latter argument is valid in the context of a strictly descriptive linguistic approach; but the descriptive appropriateness of phonological generalizations does not, of course, imply that such generalizations are components of the mental representation of language. We do not know what is elegance and insightfulness in the latter context. It is highly interesting if generalized phonological mechanisms can be demonstrated to have a mental counterpart, but one does not ever achieve that goal by just showing that rules "work". It seems to me more useful to examine whether there is perhaps something else that works. It is only in cases where one cannot envisage other, equally or more plausible, models accounting for speakers' use of their language that it is likely to be really rewarding to make comprehensive research on the possible "psychological reality" of phonological mechanisms.

From this point of view I find it worth while taking a phonological phenomenon such as vowel harmony (or other assimilatory mechanisms) which really presents a strong case for the adequacy of phonological generalizations, and to see if the relevant data can be handled entirely without specific phonological machinery,[1] viz. by putting more stuff into the "lexicon". I think the dyad approach is, in principle, an interesting alternative to formulaic phonologies because it does not make any reference whatsoever to the specific phonological structure

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1) By "specific" I here mean: specific to the statement of this particular regularity, as against general mechanisms such as the arrangement of items in a sequential order manifested as temporal order.

of the constituents that make up wordforms, but only to the quite general criterion of greater or lesser partial similarity among dyads. Notions such as "segment", "feature", "(segmental) environment", "alternation" (or "X becomes Y") have no place in this model; it is in fact <u>aphonological</u>. That is the interesting property of it. (Other aphonological models might serve the purpose of the argument equally well.)

Accordingly, the question is not whether the dyad approach looks more or less silly from the point of view of current phonological theories but whether or not this kind of model fails (totally and irreparably) on some capital point.

In the beginning of this lengthy discussion of formative dyads I mentioned that loanwords and other foreignisms would be disregarded for a moment. Now they must be taken into consideration. It is of crucial importance whether there is evidence for a <u>productive</u>, creative use of some phonological mechanism in establishing new formative dyads, or new variants of formative dyads. A study of lexical borrowing is one approach to the solution of that question (along with studies of language acquisition and language change).

As I see it, examples such as KF /kaagi⌜ɋɋiiniit puu⌜lu-luuniit/ 'either a cake or a ball' are clearly indicative of the use of a generalization referring to configurations of segments. At the time when the Danish words <u>kage</u> and <u>bolle</u> came into the dialect, the pattern of "i-dialect" was already there (there is indisputable evidence for "i-dialect" in southernmost Greenland in the earliest phase of colonization). The possibility of extending this pattern to newly acquired lexical items, proves the existence - at the time of borrowing, at least - of a synchronic regularity that is sensitive to the specific vowel qualities of successive syllables.

This, then, is the core of the matter: phonological generalizations emerging from a corpus of wordforms do not constitute evidence for the (synchronic) mental reality (in any sense of this term) of the regularities in question, even though the finding that the generalizations hold for any size of corpus that the linguist chooses to work with, may be strongly suggestive of productivity. On the other hand, the dynamics of language, as it appears in the process of borrowing (<u>inter alia</u>), may give the irrefutable proof. If sequences containing borrowed items are operated upon in accordance with a well-established phonological generalization, this must be substantial evidence for the relevance of that generalization to the speakers' command of their language (I here make use of Paul Kiparsky's classical notion of "substantial evidence" in linguistics, which is hardly a controversial issue today, although it has not quite had the practical effect on linguistic work in the more recent years that one might expect).

It must be emphasized, at this point, that the processing of borrowed lexical items only testifies to the existence of <u>some kind of phonological mechanism</u> (as against the lexical storage exemplified by the dyad model). It does not necessarily give us any hint as to <u>the nature of that mechanism</u>. In the case of "i-dialect" the evidence just tells us that the conditioned alternation of /u/ and /i/ is, or rather was at some time, a psychological reality. Whether it is appropriate to describe that regularity in terms of a rule replacing /u/ by /i/, or in terms of alternation in the strictly static sense, is not at issue as yet. We have, however, solid evidence for <u>the psychological reality of phonological conditioning</u>: /kaagiq/ has come to condition the suffix alternant with /ii/ just because it contains a front vowel, and for no other conceivable reason. This is all I wish to argue here, as far as mental representation is concerned.

Even such a modest claim as this should be taken with all appropriate reservations. Firstly, it should be understood that the loanword evidence only proves the <u>possibility</u> for a phonological regularity to be employed; it does not directly tell us anything about the way in which wordforms in general are handled by "i-dialect" speakers. If a descriptive model makes psychological claims, it is wise to consider these as claims about phonological regularities which the speaker(-listener) may make use of rather than claims about his actual strategy. It must be understood once and for all that there is a practically infinite capacity of lexical storage at his disposal.

Secondly, it must be stressed again that the loanword evidence is temporally limited. "i-dialect" speakers today, who use suffixal /i/ for /u/ after /kaagiq/ 'cake', may not have access to any phonological conditioning pattern. If they use suffixal /i/ (not /u/) quite regularly after /kaagiq/, it may be because they master the fact that this lexical item "takes" suffixes in /i/ rather than /u/; if this is true, they still master a phonological regularity since the alternation between /u/ and /i/ is involved, but the conditioning is no longer phonological. However, it is also possible that neither the phonological conditioning nor the phonological alternation is mastered as such any longer: this means either generalization of one alternant or complete lexicalization of formative clusters, and this is the point where the phenomenon ceases to have any phonological content.

From the point of view of phonological typology one may be content with the finding that there has been some kind of psychological reality associated with the phonologically conditioned alternation between /u/ and /i/, and I shall leave it at that here. Nevertheless, it may be of separate interest to trace the fate of this pattern in some particular dialect (for contemporary speakers this may be done by "experimental phonological" methods, as suggested by John Ohala). It would be interesting to know exactly under which circumstances, and at which rate, a phonological regularity is likely to decay.[1]

If, now, we consider the pattern of "i-dialect" as a fully operative phonological regularity, the question is how to state it. What does such a mechanism do, and what kinds of representations does it operate upon? I shall touch upon these questions in the next section. To avoid being misunderstood, I shall emphasize again that the following discussion in terms of rule formulation etc. is strictly descriptive: it entails absolutely no claims about the nature of internalized phonology, except for the very claim that it is possible for the "i-dialect" pattern to be mastered (somehow) as a phonological regularity.

4.2 Directionality and underlying representations[2]

As shown in section 3.2, etymological /u/ in a non-initial syllable may be continued as /u/ or /i/. If none of the constraints (a), (b), and (d) apply, the vowel reflex will be dependent upon the vowel of the preceding syllable. In section

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1) "Assibilation" in Greenlandic is a typical example of a decaying rule, cf. Rischel (1974, p. 260-275). Again, a study of loanwords turns out to be rewarding. For example, it may be observed that the participial suffix /tuq/ becomes /suq/ by assibilation after syllables with /i/ in loanwords of a certain age. Hence one says /hiisøiʳssuq/ (not /hiisøiʳttuq/) 'one who rides a horse; rider' (from /hiisøi/, Danish hest 'horse'), whereas there seems to be vacillation in /sikkiliʳssuq/ or /sikkiliʳttuq/ 'one who rides a bicycle' (/sikkili/, Danish cykel) and no assibilation at all in /piiliʳttuq/ 'one who drives a car' (/piili/, Danish bil). - Note that the treatment of the loanword stems is essentially the same in all instances, viz. addition of final /i/, but this added syllable does not have the same conditioning effect with regard to assibilation in recent loans that it used to have.

2) The term "directionality" is used here in accordance with Eliasson 1974 and Rischel 1974.

3.2 it was suggested that we get /i/ unless constraint (c) applies; in section 3.3 it was suggested that we get /i/ only if the conditions for distant assimilation (delabialization harmony) with the preceding syllable are met. In terms of underlying representation these statements may be considered equivalent: we have underlying /u/ which sometimes shifts into /i/. But is there <u>synchronic</u> evidence for anything but an alternation set /u/∼/i/: is it possible to argue in favour of underlying /u/ on a synchronic basis?

Word initial syllables have /u/, not /i/, as a continuation of /u/. It makes absolutely no sense to speak of anything but underlying = surfacing /u/ in this position, e.g. in /u¢i^{r}p-puq/ 'returns' versus /i¢i^{r}ppuq/ 'awakes'. It is interesting what happens if the alternating vowel of a suffix comes to stand in a word initial syllable, or if the invariant vowel in the first syllable of a base comes to stand in a non-initial position. Unfortunately, it is hard to find evidence of this kind, since the categories of word initial and non-initial formatives are largely complementary. However, there is at least one interesting formative, viz. /una/ 'that one' (or: 'it is'). If occurring as a separate word it invariably has /u/: /una/, but it may be attached "enclitically" to another form, and in that case it follows the rules of /u/ - /i/ alternation: KF /iɋɋinina/ 'is that one yours?', Alluitsoq /iLLiina/ (id.), versus /u^{r}ssuruna/ 'that is blubber (/u^{r}ssuq/)'. Since /u/ and /i/ are equally possible, from a surface phonotactical point of view, in word initial syllables, the behaviour of this formative is evidence that /u/ is the neutral reflex of the alternating set. It is the alternant which occurs when no conditions are specified. I think it is useful to interpret the concept of "underlying representation" as meaning just that.

I assume, therefore, that insofar as there is a synchronic rule it is statable as a rule that specifies conditions under which /i/ occurs instead of the neutral representation /u/, rather than a rule that specifies conditions under which /u/ occurs instead of /i/.

This solution is supported by a simplicity criterion: a rule to the effect that /u/ goes to /i/ under specific conditions, is found to apply rather regularly (although some formatives, or formative clusters, must be marked as exceptions). If, on the other hand, the rule were made to state that /i/ goes to /u/ under specific conditions, it must be marked for every formative with /i/ whether this vowel can or cannot undergo the rule. That is, the degree of predictability is incomparably much higher under the former analysis than under the latter.

By the convergence of these two criteria the alternation seems clearly characterized as an asymmetric one. It thereby differs from the regularity observable in languages with a strict pattern of vowel harmony, and - as I argued in section 1 above - that difference is typologically interesting.

As for phonological formalization, the implications of this conclusion are as follows: it is legitimate to represent the alternation set as /u/ on an abstract level of description (it is not an ambivalent segment in the sense of Rischel 1974, p. 346 ff), and to set up a unidirectional rule of distant assimilation. The rule in question must produce a delabialization (unrounding) of /u/ after a syllable with an unrounded vowel, but there are two sets of restrictions associated with it. Firstly, the applicability of the rule is constrained by conditions on the structural description: /u/ does not undergo the rule if immediately preceded by a consonant or consonant cluster containing a feature of labial articulation (constraint (b) of section 3.2), and in some dialects it does not normally undergo the rule if the following syllable has a rounded vowel (constraint (d)). Secondly, most dialects prohibit the rule from reapplying to a form (i.e., /u/ cannot be assimilated to /i/ of a preceding syllable if that vowel, in turn, represents underlying /u/). - I do not think it is very interesting (in the present, rather floating state of linguistic formalization) to go into details about rule algebra; the remarks above will probably suffice to characterize what the rule does, and does not.

The rule works without any difficulties in most types of forms. But what about KF /aaɖuuniit/ 'or blood', /aniɖɖuni/ 'going out', etc. without the expected change of /u/ (/uu/) into /i/ (/ii/)? Diachronically, these exceptions are due to constraints (c) and (b), respectively (see section 3.2, end), but synchronically it is most reasonable to speak of lexicalization: /aak/ is lexicalized as a base which fails to <u>trigger</u> the rule; /ɖɖu/ is lexicalized as a suffix which fails to <u>undergo</u> the rule unless it follows after a consonant stem (as in /siniɖɖini/ 'sleeping', cf. /sinik/ 'sleep'). In certain instances, however, the conditioning segment is synchronically transparent, cf. /aaŋŋuuq/ 'yes, it is said' from /aap/ 'yes', but it may also be more reasonable to posit lexicalization here than to operate with "bleeding" order between the rule of distant vowel assimilation and the rule of consonant assimilation. - In the framework of the dyad approach outlined in section 4.1, lexicalization would imply that dyads consisting of /aa(k)/ plus something else, and dyads consisting of a vowel stem plus /(ɖ)ɖu/, etc., are lexicalized only in variants with /u/ (in the appropriate position) as a continuation of etymological /u/.

The final question is: to what extent is etymological /u/, reflected as /i/, synchronically recoverable? Is it still transparent, in the majority of cases, that we have an alternation set which can be reduced to underlying /u/, or is it so that the majority of forms containing /i/ as a reflex of /u/ have undergone restructuring (so that one must now speak of invariant, underlying = surfacing /i/)? I shall briefly review the conditions in various positions.

(i) Etymological /u/ in a word initial syllable is always preserved.

(ii) Etymological /u/ in the initial syllable of a suffix may behave in three ways: (a) The vowel is preserved if the suffix itself is "irregular" or meets the structural description of some constraint on the vowel shift (examples in the KF dialect: /pu(q)/ 'indicative mood'; /kuluuq/ 'big'). - (b) The vowel alternates if the suffix is subject to no constraint (numerous examples above). - (c) It is theoretically possible that the vowel may occur only as /i/ if the suffix occurs only after stems whose last syllable has /a/ or /i/, but I can think of no such examples.

(iii) Etymological /u/ in the final syllable of a bisyllabic or polysyllabic formative may behave in three ways: (a) The vowel may be preserved "irregularly" or by a constraint (cf. (ii,a) above with the example /kuluuq/). - (b) The vowel alternates as conditioned by the following formative (if the dialect has constraint (d) of section 3.2: /itøiir+puq/, /ittuur+tuq/). - (c) If a dialect does not at all make use of constraint (d) of section 3.2, formative final /u/ may be reflected consistently by /i/ (provided that none of the constraints (a), (b), (c) of section 3.2 apply within the formative).

(iv) Etymological /u/ in an internal syllable of a polysyllabic formative may behave in two ways: (a) The vowel may be preserved "irregularly" or by a constraint (examples: the second syllable of /puugutaq/ 'plate', /qipuqqaq/ 'humpback whale'). - (b) If there is no constraint on the shift of /u/ to /i/, the vowel occurs only as /i/ (example: /ikusik/ reflected as /ikisik/ 'elbow').

According to this taxonomy, there are three sets of conditions under which etymological /u/ may be reflected consistently as /i/, viz. (ii,c), (iii,c), (iv,b). The first of these is entirely theoretical and will be disregarded here. The second may be exemplified by formatives such as /inuk/ 'human being' in a dialect which does not at all know constraint (d) (if such a dialect exists), i.e. a dialect in which /inuk/ has become /inik/, /inuttu^{r}ttuq/ 'who eats human flesh' is /initti^{r}ttiq/ or /init¢i^{r}t¢iq/, etc. etc. I have at present no data for such a dialect; the Upernavik and East Greenland material that I have seen is suggestive of a sporadic use of the constraint in question, and I cannot decide whether there is any formative which never partakes in it. Moreover, even if there is such a formative, /i/ from /u/ will differ from etymological /i/ in that there occurs a labial glide between this vowel and the initial vowel of a following formative (unless that vowel is /u/→ /i/): even if the second syllable of /inik/ is always /i/, the possessive form /ini^{v}a/ 'its occupant' and the plural /ini^{v}it/ 'human beings' betray the specific status of /i/ (as against /panik/ 'daughter', /pani^{j}a/ 'his daughter', /paniit/ 'daughters'). In that case one may claim that a formative with etymological /u/ is restructured with /i/ plus a labial glide, e.g. that /inuk/ is restructured as underlying /ini^{v}k/, whose labial appears on the surface <u>if</u> the final consonant is deleted before a suffix vowel. However, this solution introduces an underlying representation which is never surfacing in the southern dialects of modern WG. Since the surface forms would be just as predictable from underlying /inuk/, I see no compelling reason to speak of restructuring. (There is a further criterion in West Greenlandic dialects showing that /i/ from /u/ remains functionally different from etymological /i/: if the former occurs before a suffix initial /u/, and the two together are shifted, we get a long vowel /ii/, cf. /qiṣuk+uṣaq/ 'resembling wood' reflected as /qisiisaq/, whereas etymological /i/ plus suffix initial /u/ are reflected in many cases as bisyllabic /i^{j}i/ or /i-i/, cf. /malissavi^{j}uk/ 'are you going to follow him', KF /malissavi^{j}ik/.) - It must be repeated that this situation is hypothetical, given the data that I have examined.

There remains just one genuine possibility of restructuring of etymological /u/ to /i/, viz. if the vowel occurs in a <u>formative internal</u> syllable (condition (iv,b)). In the southernmost dialects of West Greenland forms such as /ikisik/ 'elbow', /asiki^{j}aq/ (from /asuki^{j}aq/) 'I do not know' may have entire restructuring. In other dialects, however, the "history" of /i/ may be betrayed by a more or less optional retention of the labiality feature of etymological /u/ in the form of a labialization of the following consonant or consonant cluster. I think it is extremely likely that such labialization used to occur in the southern dialects as well.

To sum up: it is only in syllables that are neither immediately preceded nor immediately followed by a formative boundary that there is no possible alternation of /i/ (from /u/) with a rounded vowel, or a cluster consisting of a vowel plus a labial glide, to betray the special status of /i/. In most forms the underlying feature of rounding is recoverable. Hence, the phenomenon of "i-dialect" invites a generative treatment in terms of rules. Since these rules are essentially correspondence rules between the standard language and "i-dialect", they may be used e.g. for pedagogical purposes, if there is any need for that.

It is an interesting question to what extent the alternation patterns betraying the origin of the changed vowel are mastered actively by speakers of "i-dialect". There is a specific issue which has not been touched upon in this paper: to what extent are these alternations employed in transforming dialect forms into standard WG, e.g. in writing? Investigations of errors in forms with recoverable versus irrecoverable etymological /u/ may throw light upon this question.

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ON THE PHONOLOGICAL INTERPRETATION OF THE FALLING DIPHTHONGS IN DANISH

Hans Basbøll

__Abstract__: 'Diphthong' is here taken to be a phonetic and not a phonological concept. The meaning of the term 'diphthong' is discussed in section 2, and the classification of (Danish) diphthongs into rising and falling in section 3.1. Section 3 contains proposals as to the phonological treatment of the falling diphthongs in Danish from several angles. In section 4, finally, we shall ask and try to answer the question: can 'diphthong' in any sense be considered a phonologically (i.e. functionally) relevant concept in Danish?

1. Introduction

The point of departure of the present analysis lies within phonetics, and we try to argue from the phonetic facts towards a functional interpretation of the diphthongs. The general orientation of the paper is thus of a structural type (the criteria chosen will be discussed in section 3). But although I shall not give any generative rule formulations in this paper, it should be emphasized that I consider a generative analysis a useful complementary tool to more traditional phonological descriptions, and generative considerations will be explicitly included in the discussion.[1]

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1) Section 3 of the present paper is a condensed version of parts of my mimeographed notes (Basbøll 1973a), which contain a detailed generative - as well as structuralist - analysis of the Danish diphthongs. The contents of sections 2 and 4 were first presented at a guest lecture held at the University of Aarhus on March 18, 1975. I am indebted to Eli Fischer-Jørgensen, Steffen Heger, Peter Holtse, Jørgen Rischel, Nina Thorsen and Oluf Thorsen for helpful comments on the manuscript.

2. What is a diphthong?

As already mentioned, 'diphthong' will in this paper be considered a phonetically defined concept. This does not, of course, exclude that 'diphthong' might also (or might alternatively) be defined as a phonological (or functional) concept, cf. section 4. Below, I shall briefly discuss a widespread traditional definition of the (phonetic) diphthong, but I will include only a very limited part of the general literature on diphthongs, since the main purpose of the paper is the phonological analysis of Danish diphthongs, not the phonetic nature of diphthongs, nor a survey of diphthongs in a number of languages.

2.1 A traditional definition

A very widespread definition of a 'diphthong' runs approximately as follows: "A diphthong is a sequence of two vowels in the same syllable" (cf. Jespersen 1897-99, p. 549). Other definitions attempt to avoid including the syllable in the definition, e.g. by speaking of a close-knit (or tight) sequence of vowels or of complex vowels (cf. Pike 1947a, p. 236), or of a gliding vowel (cf. Jones 1934, p. 57). The reason why "a sequence of two vowels" is an insufficient definition is shown by words like Aïda in Danish: [aǐ:da] (where [ǐ:] may even be preceded by a glottal attack), in which no one would classify [aǐ:] as a diphthong. I do not see, however, why it should be an improvement to exclude "in the same syllable" from the definition *if* the other reservations mentioned are only less precise ways of expressing approximately the same thing. But the term 'gliding vowel' may be an apt characterization of (at least certain types of) diphthongs, cf. section 2.3 below; the terms 'complex vowel' and 'close-knit sequence of vowels' may also suggest something different from 'homosyllabic', viz. that the sequence should function like a single vowel, but then it will no longer be a purely phonetic definition.

2.2 Explication of the concepts entering into the definition

The statement "A diphthong is a sequence of two vowels in the same syllable" can, of course, be accepted as a well-defined (or valid) definition only to the extent that the concepts entering into the definition are well-defined (or valid). Below I shall discuss what is meant by 'sequence' (section 2.2.1), 'vowel' (2.2.2) and 'syllable' (2.2.3). Although the meaning of the word "two" is uncontroversial, it is nevertheless not entirely unproblematic what it means that there should be two vowels, in contradistinction to, say, one, three or infinitely many. The distinction between a monophthong and a polyphthong will be discussed in section 2.2.4, whereas the distinction between a diphthong and a triphthong will be taken up in section 2.2.5. In section 2.3 I shall conclude this part of the paper by slightly rephrasing the traditional definition.

2.2.1 What does 'sequence' mean?

In the definition, 'sequence' means that the two vowels in question are not simultaneous (which seems obvious) and, furthermore, that they must be adjacent. It may be possible, however, to leave the word 'sequence' out of the definition altogether, viz. if it is universally true that two (phonetic) vowels within the same syllable are never separated by a (phonetic) consonant.

The theoretical status of the last-mentioned statement depends on the conception of a syllable (see section 2.2.3 below). If the syllable is defined as a top of sonority (where all (phonetic) vowels are more sonorous than all (phonetic) consonants), cf. Jespersen 1897-99, p. 521 ff, then it becomes a truism that two homosyllabic vowels cannot be separated by a consonant. If, on the other hand, the syllable is taken to be an immediately given entity (e.g. a psychologically real unit), then the statement that two homosyllabic vowels are never separated by a consonant is an empirical one - or maybe part of the more general empirical statement that the syllable is a top of sonority - which is in principle falsifiable by confrontation with new empirical data (e.g. when a hitherto unknown language is discovered), presupposing that sonority can be objectively measured.

As a matter of fact, Hjelmslev (1951, p. 17) seems implicitly to have made contiguity within the syllable part of his definition of a (functional) 'vowel': Hjelmslev phonemically identified the syllabic [u] and the non-syllabic [u̯, v] as manifestations of the taxeme /u̲/, and, similarly, the syllabic [i] and the non-syllabic [j] as manifestations of the taxeme /i̲/. But whereas the taxeme /u̲/ is considered to be both selected and selecting (i.e. to <u>function</u> both as a (phonemic) vowel and a (phonemic) consonant), the taxeme /i̲/ is considered a normal (functional) vowel <u>because [j] can never be separated from the vocalic nucleus</u> (cf. <u>elv</u> 'torrent' [ɛlʔv]/'ɛlu/). This reasoning is dubious for several reasons and has been criticized e.g. by Povl Skårup and Henning Spang-Hanssen, see Basbøll 1972a, p. 176 ff (with references).

2.2.2 What does 'vowel' mean?

It is clear that 'vowel' in the present context must be a phonetically defined concept, and not a functionally defined one. A good definition seems to be Pike's (1943, p. 78) of 'a vocoid' as (approximately) a central oral resonant. Ladefoged (1971, p. 91) considers [consonantal] to be a "cover feature", i.e. a feature which is definable exclusively in terms of features already defined. He does not define it explicitly, however, but I shall follow his suggestions and use the term (phonetic) vowel (or 'vocoid') as designating the class of [-consonantal] segments, defined by the following equivalence (cf. Basbøll 1974, p. 99 f):

$$[-\text{consonantal}] \equiv [+\text{sonorant}, +\text{continuant}, -\text{lateral}],$$

where [sonorant] is defined, in agreement with Ladefoged, as an acoustic-auditory concept, and where [-continuant] (equivalent to Ladefoged's [+stop]) is defined as having complete closure in the mouth channel (at least once during the articulation). It is a consequence of this definition of the phonetic vowels that the class of phonetic consonants (or 'contoids' in Pike's terminology) is the union of the non-overlapping classes of obstruents, non-continuant sonorants and sonorant laterals:

$$[+\text{consonantal}] \equiv \left\{ \begin{array}{c} [-\text{sonorant}] \\ \begin{bmatrix} +\text{sonorant} \\ -\text{continuant} \end{bmatrix} \\ \begin{bmatrix} +\text{sonorant} \\ +\text{lateral} \end{bmatrix} \end{array} \right\}$$

The main advantage in operating with [consonantal] as a cover feature in Ladefoged's sense, is its definition by means of independently needed features which are all much more clearly defined than proposed independent definitions of [consonantal], [vocalic], and so on. This procedure also excludes the possibility of ill defined and dubious categories "in between" phonetic vowels and consonants, such as glides according to Roman Jakobson's system, for example (in the present paper I use the term "glide" for a [-consonantal, -syllabic] sound, i.e. "glide" is here defined by means of syllabicity, which is a feature of quite another sort than the other features mentioned).

All voiceless and fricative sounds are obstruents (i.e. [-sonorant]), according to the present definition; thus voiceless nasals and fricative laterals are obstruents, but they still belong to the natural classes of [+nasal] and [+lateral] sounds, of course (phonemically, all nasals and laterals in Danish can be considered voiced). Voiced nasals are non-continuant sonorants. If the passage of air through the mouth is completely blocked throughout the articulation, the only sonorant possible is a nasal. But with the present definition of the feature [continuant], a sound is [-cont] also if there is a complete closure in the mouth channel during only one moment, or during a few (discrete) moments, of the articulation. Thus normal vibrants ("trills"), taps and flaps are also to be considered [-cont], just like they are classified as [+stop] according to Ladefoged 1971, p. 108.[1] Such non-continuant r-sounds are therefore always [+consonantal]. Other r-sounds are either obstruents (all voiceless r's, of course, as well as e.g. the initial [ʁ] in Danish), or they are sonorants and therefore [-consonantal], since they are neither nasals or laterals, nor trills, flaps or the like. It is an open question whether all "r-sounds" constitute a natural phonetic class. Furthermore, I think that the relatedness of l- and r-sounds which probably exists (together they constitute the class of "liquids") is an auditory (and not an articulatory) phenomenon, i.e., I propose the auditory feature [liquid] recognized, cf.

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1) Trills, taps and flaps were not included in my earlier discussion of distinctive features, all Danish r's being [+continuant]. (In a universal phonetic framework, a special feature "vibration" is probably demanded, cf., e.g., Ladefoged 1971, p. 55 f.)

the auditory feature [grave] (such an auditory feature should, of course, be established by means of auditory tests). It is possible, however, that an auditorily defined class of "liquids" will turn out not to be coextensive with the union of all laterals and (what is generally termed) r-sounds; in that case, the conclusion would invite itself that the term "liquid" has (sometimes, at least) been used on the basis of historical and distributional evidence alone, i.e. not necessarily designating a natural phonetic class.

According to the definitions adopted here, the natural class of consonantal sonorants in Danish consists of (voiced) nasals and (sonorant) laterals, but excludes r-sounds (since /r/ in Danish is never manifested by trills, flaps or the like). The establishment of this natural class agrees well with facts in Danish phonology, in particular the following one: before consonantal sonorants (i.e. nasals and /l/) there is a stable opposition of vowel quantity (e.g. pæn, pen; mile, milde [pɛ:ʔn, pɛnʔ; mi:lə, milə]); before obstruents as well as before non-consonantal (but non-syllabic) sonorants, i.e. "glides", on the other hand, either only short vowels are found (with a few exceptions), this is the case before plosives and [f], and before [j] in conservative standards; or there is a great deal of vowel length vacillation, both in alternating pronunciations of the same word (e.g. bor 'lives, v.', bider 'bites, v.' [bo:ʔɒ̯/boɒ̯ʔ, bi:ʔðʌ/biðʔʌ]), and in the same morpheme in different words (e.g. bad 'bath', bade 'baths'; gris, 'pig', grise 'pigs', grisesti 'pigsty' [bað, bæ:ðə; gʁi:ʔs, gʁi(:)sə, gʁísəsdì:ʔ]).

If a diphthong is defined as two adjacent homosyllabic vowels defined as above (viz. as [-consonantal] segments), then all groups of a Danish [ð] (which is phonetically a sonorant) and a preceding vowel must be considered (phonetic) diphthongs. This consequence has also been drawn e.g. by Heger (forthcoming). However, they will thus constitute a special type of diphthongs, see section 2.3 below (and cf. section 4).

2.2.3 What does 'syllable' mean?

In the present context 'syllable' is, of course, a phonetic and not a phonemic concept. It is impossible in this paper to present a general discussion of the syllable (cf. Kloster Jensen 1963). Suffice here to say that syllables may be considered as tops of sonority (cf. section 2.2.1 above), with a non-consonantal center (which may be a mono-, di- or triphthong) and a voiceless margin, separated by consonantal sonorants and voiced obstruents, respectively (see Basbøll 1974).[1] In the communication process, syllables may function as a means of structuring the sound chain so that it becomes easier to encode and decode (cf. Kim 1971). This structuring thus belongs to the expression plane of language (in Hjelmslev's terminology), as opposed to the structuring into morphemes which is a projection of higher level information into the expression chain (this does not exclude, however, that certain syllable boundaries are located depending on the occurrence of specific grammatical boundaries, cf. Basbøll 1972b and forthcoming).

2.2.4 Monophthong or polyphthong?

It is, of course, well known that there are no sharp limits between successive sound segments on the articulatory level: there is a constant coarticulation between adjacent sounds, the transition from one sound to the next one is smooth, and it is often impossible to tell where one sound ends and the next one begins. At least for the non-consonantal part of the syllable this indeterminacy of limits on the articulatory level is matched by an indeterminacy on the acoustic level too (whereas e.g. the limit between certain consonants and the vowel can be well-defined, as in the case of voiceless fricatives, even though the acoustic structure of each of the sounds is influenced by neighbouring sounds). The question thus arises what is meant by '<u>two</u> vowels' in the definition. This

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1) Needless to say, both consonantal sonorants, voiced obstruents, and the voiceless margin are <u>optional</u> in the syllable.

is evidently part of the general question of segmentation which, however, cannot be dealt with here. Notice that it is not sufficient to refer to the commutation test at this place, since we are explicitly dealing with phonetic diphthongs (the criterion that the sound chain is segmented into as many units as are separately commutable will be used in section 3.5.1). It thus seems that there are, phonetically speaking, an excessive number of successive vowel quality shades in both kan, Kain and jer ([kan?, ˈkɑ̭i̭?n, i̭æɒ̭]). What is the justification for claiming that the first word contains a monophthong, the second one a diphthong, and the third one a triphthong? This question will be discussed in two tempi: (1) when the quality of every vowel is influenced by its surroundings, how do we distinguish between a monophthong and a polyphthong (this section), and (2) provided that we have a polyphthong (according to (1)), how do we distinguish between a diphthong and a triphthong, etc., when in both cases there are an excessive number of different vowel quality shades? (section 2.2.5). These considerations will be concluded in section 2.3.

It has recently been claimed (Heger forthcoming and this volume; Brink and Lund 1974, p. 30 and forthcoming, § 15) that Danish words like græs, traditionally described [gʁæs, gʁas] (or, in the Danish transcription system Dania, [gräs]) in fact contain an "ultra-short diphthong" (starting at a higher F1 value than what seems to be conditioned by [ʁ]), which would most adequately be transcribed [ɑ͡a] or the like. Heger bases his claim on formant measurements. I shall not try to settle this question here, but only point out what I consider relevant for the decision of the issue.

First of all, in order to accept that the vocalic part of a syllable is not a monophthong, the gliding should, of course, be perceptually recognizable. But this is not enough, since one can be trained to hear differences (transitions) which are not generally perceptible. Only if the gliding cannot be accounted for as the simplest way (a notion which should be made more precise) from the target of the prevocalic consonant via the vowel target (which may, however, not be reached if the vowel is short) to the target of the postvocalic consonant, are we justified in concluding that the vocalic part in question is not a monophthong. Notice that this decision cannot be made from the acoustic or auditory data alone, but that it presupposes knowledge of the complex relationships between the movement of the articulatory organs and their acoustic (and auditory) results.

2.2.5 Diphthong or triphthong?

The considerations above also suggest the criteria for distinguishing between a diphthong and a triphthong: If the change of quality in the vocalic part of a syllable cannot be accounted for by two vowel targets, but presupposes a third vowel target, situated in time between the two others, then it is a triphthong. Thus [ɑi̯], with a gliding from about a low mid unrounded vowel and ending with, e.g., an [ɛ̯] or [e̯], can be accounted for as the simplest way between two targets (of which the second one may well be a higher vowel than the one which is actually reached, see section 2.3 below); in [i̯ɑu̯], on the other hand, the simplest way from [i̯] to [u̯] is by no means via a low vowel like [ɑ], and there must thus be a third target in between the other two, with the consequence that [i̯ɑu̯] should be considered a triphthong. This account is in full agreement with usual practice (and comes close to statements of Trubetzkoy and many others).

2.3 Conclusion of section 2

The reflections of the preceding sections may be condensed in the following general definition of an n-phthong: "a perceptible change of quality ("gliding") within the non-consonantal part of one syllable is an n-phthong, provided that it cannot be explained as the result of the simplest movement between the target of the preceding consonant (if there is any), n-1 different vowel targets, and the target of the following consonant (if there is any), and provided that it can be explained with the addition of one more vowel target to the above information".

The definition just given includes combinations of a vowel and a following (Danish) [ð] in the class of diphthongs. These groups differ, however, from the other Danish diphthongs in that [ð] need not be considered to lie within the normal vowel space (e.g. within the limits of Jones's Cardinal Vowel diagram), cf. its coronal place of articulation. If it seems preferable, the definition of an n-phthong might be modified so as to exclude the [ð]-combinations, viz. by adding the reservation "(change of quality) within the normal vowel space", or by excluding vowels with coronal articulation (but cf. the retroflex vowels). It is, as far as I can see, a purely terminological question how these [ð]-groups should be handled. In the following I do not consider them to be diphthongs, but the arguments given would remain essentially unaltered if they were included.[1] See further sections 3 and 4.

One further consequence of the definition of diphthongs in terms of vowel targets necessary in order to explain the movement in question should be mentioned. In falling diphthongs like Danish [ɑu̯, ʌi̯] (see section 3.1 below), it is irrelevant where, exactly, the gliding stops: only its starting point and direction seem to matter perceptually (this is, of course, a well-known observation). The point is that the same two vowel

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1) If the [ð]-groups were included in the class of diphthongs, the widespread sound change in Danish dialects ð > j could not be described as a "diphthongization" of the Vð-sequences; again, the matter seems to be terminological, but the choice may nevertheless have one phonologically relevant consequence: if the Vð-sequences are "diphthongized" in many different dialects, and if this terminology is phonologically justified, this could be a generalization of the phonological rule of diphthongization in Danish to include all sequences of vowels plus underlying voiced fricatives.

targets can explain the movement, irrespectively of the exact ending point of the gliding. Thus [ɑɛ̯, ɑe̯, ɑi̯] etc. can be considered the *same* diphthong phonetically, defined in terms of vowel targets.

What is the justification for the notation of the second part of the falling diphthongs in Danish as [i̯, u̯, ɒ̯] instead of, say, [e̯, o̯, ʌ̯] or [j, w, ʁ]? First of all, vowel symbols are used for the second component since it can never be pronounced as a phonetic consonant, and this is in full agreement with the characterization of a diphthong as involving a gliding within the normal vowel space. Second, we have chosen to use one single symbol for the second component of e.g. [iu̯, eu̯, ɛu̯, ɑu̯], although the actual "endings" are more and more open vowels, from about [u̯] to about [o̯] or [ɔ̯]. These second parts of the diphthongs in question have been identified in agreement with normal notational practice, since they represent communicational constancy and stylistically (in the broad sense) only quite insignificant variability.[1] The choice of the extreme

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1) This characterization of "normal notational practice" is, of course, very crude. Communicational constancy (i.e. non-contrastiveness) is generally considered a *sine qua non* for the notational identification, but if it is taken to mean that any *sound* difference which *can* by itself distinguish between two *utterances* within the language norm described should be observed in the notation, then it is, in fact, a very strong criterion. As an example, consider the vowels (normally analysed as bound variants) [æ] and [a] which *can* distinguish between two utterances in cases like the following: the preterite *bad* 'asked' in pretonal position can be [bæð...] or [bað...] (cf. the stressed form [bæ:ʔð/bæðʔ/baðʔ]), whereas the noun *bad* 'bath' is always [bað], in stressed as well as unstressed position (an example of potential commutation would be *bad om gódt véjr* 'asked for fair weather' [bæð/bað...] vs. a constructed name for a sea-bath *Bad "Om gódt véjr"* [bað...]); or consider the glottal attack which can by itself distinguish between *en ål* 'an eel' [en(ʔ)ɔ̄:ʔl] vs. *en nål* 'a needle' [en(n)ɔ̄:ʔl]. The strength of this criterion of communicational constancy is to a high degree, of course, dependent on the number of "diacritic signs" used in the transcription, like space (for word boundaries), syllable

(cont. on the next page)

vowels [i̯, u̯, ɒ̯] as symbols can be defended for two reasons: they represent possible second parts for some of the diphthongs, at least, and they represent the points where the gliding crosses the limit of the vowel space; and, secondly, they can be said to represent the cross point of the glidings from different starting points, thus recalling the idea of formant "loci" (so that the locus of e.g. F_2 of a [b] should be the cross point of the (extrapolated) F_2 in [bi], [ba], [bu] etc., in some sense). If this interpretation is used, the common ending point of the different [u̯]-diphthongs (i.e. [iu̯,ɛu̯,ɒu̯] etc.) is an abstraction, whereas the common ending point of different pronunciations of [iu̯] is a generalization of a type which is inevitable in all systematic phonetic transcription.

At the very end, the information we look for in order to decide between a monophthongal or a diphthongal phonetic analysis probably is whether one or two vowel segments are encoded. At the time being, however, this question does not seem to be approachable by any direct methods (such as observation of the encoding process).

3. Diphthongs in Standard Danish

The following pages contain a phonological analysis of the phonetic diphthongs in Standard Danish, i.e. the [i̯]-, [u̯]-

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(continued)
boundaries (e.g. indicated by the location of stress symbols like ' and ˌ), and so on. It also depends on how many potential distinctions between utterances are assigned to prosodic features like stress and intonation, as compared to the sound chain itself. In short, this problem is very complicated.

The other condition mentioned in the text, viz. that of insignificant stylistic variability, suggests that if the substitution of one sound with another can, in any context, have a stylistic effect, then these sounds should be distinguished in phonetic transcription, although they are "free variants". (As a considerably less precise criterion one could mention the traditional condition that variants which are phonetically clearly different should not be rendered by the same phonetic symbol.)

and [ɒ̯]-diphthongs (the Vð-sequences are not considered to be diphthongs here, cf. section 4 below). I shall mainly use "internal" ("structural") evidence, but it should be emphasized that I consider "external" evidence (as obtained from productivity tests, speech errors, language interference, etc. etc.) to be indispensable for a psychologically realistic phonological analysis (cf. Pike 1947b, Avram 1957).

In section 3.1 we consider the difference between rising and falling diphthongs, and the remaining parts of section 3 concern the falling diphthongs only. We proceed by first considering the falling diphthongs which occur as alternating pronunciations of vowel-consonant-sequences (section 3.2), e.g. stiv [sdi:ʔv, sdi:ʔu̯, sdiu̯ʔ]. According to Linell's principle of psychologically central invariant structurings as identical to the maximally distinct (concrete) word forms (cf. section 4 below), these diphthongs should be considered phonemically /VC/-combinations. In section 3.3, we discuss the falling diphthongs in morphological alternation with vowel-consonant sequences, e.g. hav 'sea' [hɑu̯] (cf. have 'seas' [hæ:və]). According to Linell's concrete theory of phonology, these diphthongs cannot, in contradistinction to those mentioned in section 3.2, be considered /VC/-combinations except on an abstract level. Most other phonological analyses would, however, recognize hav as having the phonemic structure /hav/, cf. the arguments discussed in section 3.3. In section 3.4, we consider the non-alternating falling diphthongs, and we distinguish between a core of these, e.g. [œu̯] in støvle, and some residual (exceptional) cases, e.g. [yu̯] in syv.

In section 3.5 we discuss a number of functional arguments for the phonological interpretation of falling diphthongs in Danish, namely (3.5.1) commutability of the two parts of the diphthong, (3.5.2) occurrence of the stød, (3.5.3) phonotactic restrictions, and (3.5.4) occurrence of the ending /ə/. We conclude that all these arguments point in the same direction, viz. to a phonological analysis of the falling diphthongs as /VC/-combinations. In section 3.6 we investigate the question whether the analysis proposed predicts the correct manifestation of the diphthongs after /r/ ("r-colouring") - the /r/-combinations having been excluded from consideration until this point - and we conclude that this is in fact the case. In section 3.7, finally, we discuss the "b-diphthongs" and find that they can be accounted for, by and large, within the already established analysis.

Let us end this brief introduction by pointing out that the glides, i.e. the non-syllabic phonetic vowels which occur as part of diphthongs (i.e. the prevocalic [i̯] and the postvocalic [i̯, u̯, ɒ̯]) are distinguished by their place of articulation only (as palatal, velar,[1] and pharyngeal). It is important to notice that both degree of openness (in the articulatory sense, according to which [ɒ] is a narrow (i.e. constricted) pharyngeal vowel) and rounding seem irrelevant (with the possible exception mentioned in the footnote). In this respect, the glides clearly seem to function as phonemic consonants and not as vowels.

3.1 Rising vs. falling diphthongs

When two adjacent phonetic vowels in Danish occur within the same syllable, it is perceptually clear that exactly one of these constitutes the syllabic peak (cf. the Faroese diphthongs, for comparison). It follows, then, that Danish diphthongs can be divided into rising (V̯V) and falling (VV̯) diphthongs. It follows, furthermore, that Danish triphthongs have

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1) [u̯] is normally pronounced with lip-rounding, but without any possibility of contrast, with the possible exception of words like *sagn* : *savn* in certain conservative standards.

the structure V̯VV̯, and that tetraphthongs do not exist. The triphthongs (as in <u>jer</u>, <u>jeg</u>, <u>(kisse)jav</u> [i̯æɒ̯, i̯ɑi̯, (kisə)i̯ɑu̯]) can be analysed as a rising and a falling diphthong with the same peak:

$$\rlap{$\underbrace{\phantom{\underset{\frown}{\mathrm{V}}\ \ \mathrm{V}}}_{\text{rising}}$}\underset{\frown}{\mathrm{V}}\ \ \overbrace{\mathrm{V}\ \ \underset{\frown}{\mathrm{V}}}^{\text{falling}}$$

This agrees with the fact that there are no restrictions of combinability specific to triphthongs, i.e., all the phonotactic restrictions can be reduced to restrictions also applying to rising and falling diphthongs, respectively.

The rising diphthongs will not be discussed in the present paper. Suffice here to notice that they all begin with [i̯] (which may be realized as an obstruent, particularly in emphatic pronunciation), and that all criteria point towards their phonemic analysis as manifesting a /CV/-combination.[1] E.g. there are no specific combinability restrictions applying to rising diphthongs (with the possible exception of [i̯i], cf. section 4 below), and there is a full distinction of quantity in the following vowel. The rising diphthongs in Danish will here be considered, consequently, as manifestations of /jV/-sequences where /j/ is a phonemic consonant. This is in full agreement with the traditional analyses of these diphthongs.

<u>3.2 Falling diphthongs as alternating pronunciations of vowel-fricative sequences</u>

As already mentioned, certain Danish <u>words</u> are invariably pronounced with a falling diphthong (the diphthongs in question may be termed 'genuine'), whereas other words may be pronounced either with a diphthong or with a vowel-consonant sequence in-

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1) Thus, prevocalic [i̯] is devoiced after aspirates and ignored by the stød-rules.

stead (the diphthongs in question will here be termed 'non-genuine'). The genuine diphthongs are treated below, viz. in sections 3.3 (if they are in morphological alternation with a vowel-consonant sequence) and 3.4 (if they are non-alternating genuine diphthongs).

The non-genuine falling diphthongs alternating with a vowel plus the plosive [b] differ in many ways from the other non-genuine falling diphthongs which alternate with a vowel-fricative-sequence. For one thing, the alternation vowel-[b]/diphthong is *lexically* restricted, i.e. only a very limited number of all vowel-[b]-sequences may alternatively be diphthongally realized in Standard Danish, whereas the alternations vowel-fricative/diphthong are *general*, i.e. not lexically restricted (in all cases presupposing certain levels of style, see below). The non-genuine diphthongs alternating with a vowel-[b]-sequence will therefore be treated apart from the other non-genuine falling diphthongs, viz. in section 3.7 below.

Consider the following three possible pronunciations of each of three Danish words:

lov!	'promise!'	[lɔ:ʔv, lɔ:ʔu̯, lɔu̯ʔ]
lav	'low'	[læ:ʔv, læ:ʔu̯, læu̯ʔ]
bor	'lives, v.'	[bo:ʔʁ, bo:ʔɒ̯, boɒ̯ʔ]

(The three pronunciations of each of the words represent decreasing levels of style, distinctness, etc.)

There is good evidence that such forms, viz. words with *a non-genuine falling diphthong alternating stylistically with a sequence of long vowel plus voiced fricative*, phonologically contain a long rather than a short vowel (phoneme): (i) In all cases where a long and the corresponding short vowel have a different quality, it is the quality of the *long* vowel which occurs (this is the case in the three words mentioned, where the quality of the corresponding short vowels would have been [ʌ], [a] and [ɔ], respectively). (ii) When such forms are monosyllabic and stressed, they always have stød. Furthermore, stressed forms ending in e.g. stød-less [ɔu̯, æu̯, oɒ̯] hardly occur at all (cf. sections 3.3 and 3.4 below), whereas genuine diphthongs like [ɒu̯] occur freely in stressed monosyllables both with and without stød: [tɒu̯, sgɒu̯?] tov 'rope', skov 'forest' (if forms with a possible realization [ɔu̯], e.g. in lov! above, contain a long vowel phonologically, in contradistinction to forms with a possible realization [ɒu̯] which contain a short vowel, the distinction in stød-possibilities is immediately accounted for). (iii) Phonotactics points toward the same phonological analysis, e.g. a form in [-ɑu̯?n] is possible (as in navn 'name' [nɑu̯?n]), as opposed to a form in *[-æu̯?n].

Whereas pronunciations with long vowel plus [v] and with long as well as short vowel plus [u̯] in words like those mentioned above occur in most varieties of Standard Danish, postvocalic [ʁ] (i.e. [ʁ] occurring after a homosyllabic vowel) is only found in very conservative standards (historically speaking, the vocalization of postvocalic [ʁ] has thus been carried through except in these standards). In younger forms of Standard Danish, therefore, words like bor can only be pronounced [bo:?ɒ̯] or, more frequently, [boɒ̯?]. In those younger standards, such words thus contain a genuine diphthong in the sense defined in this paper. Even in younger standards which never have postvocalic [ʁ], however, words like bor otherwise behave like lav (adj.) in that the quality is that of a phonologically long vowel, with regard to stød-conditions and phonotactics, and in that there is a stylistic alternation of (phonetic) vowel length (further, see below). It may therefore seem justified to treat words like bor on a par with words like lav, also in standards without postvocalic (fricative) [ʁ] (even though the [ɒ̯]-diphthongs in question should, strictly speaking, be considered in the following, together with the (other) genuine diphthongs).

The case is a little different with words like the following:

<u>tag</u> 'roof' [tæ:ʔɣ tæ:ʔi̯ tæi̯ʔ tæ:ʔ]
<u>låg</u> 'lid' [lɔ:ʔɣ lɔ:ʔu̯ lɔu̯ʔ]

(The first, second and third pronunciation of each of the words represent decreasing levels of distinctness, style, and the like; the form [tæ:ʔ] is an old colloquial doublet which is not easy to place in a stylistic hierarchy with respect to the other forms mentioned.)

The Danish sound [ɣ] is, as far as I know, a sonorant (except when devoiced, of course) in all varieties of Standard Danish which use this sound at all. Since it is continuant and non-lateral, it must be classified as a vocoid within the framework of the present paper (cf. section 2.2.2 above), and the (homosyllabic) sequences of a vowel plus [ɣ] are then, strictly speaking, diphthongs. However, with respect to vowel quality, stød conditions and vowel length, the words which contain long vowel plus [ɣ] alternating stylistically with both long and short vowels plus [i̯] or [u̯] seem to follow a similar pattern as the words ending in [-v]/[-u̯] and in [-ʁ]/[-ɒ̯] mentioned above. Accordingly, they will be treated here, together with the representatives of the stylistic alternation between a diphthong and a long vowel plus (what is phonetically) a voiced fricative. This classification appears to permit the statement of the more significant generalizations, phonologically, in comparison to alternative classifications.

We have thus argued that words like <u>lav</u> (adj.), <u>lag</u> 'layer', <u>låg</u>, <u>bor</u> should all be analysed phonologically as containing a <u>long vowel</u>. This parallel treatment (which will be substantiated further below) agrees well with the obvious <u>stylistic</u> parallels between the corresponding pronunciations of the words in question:

	I	II	III
lav	[læ:ʔv]	[læ:ʔu̯]	[læu̯ʔ]
lag	[læ:ʔɣ]	[læ:ʔi̯]	[læi̯ʔ]
låg	[lɔ:ʔɣ]	[lɔ:ʔu̯]	[lɔu̯ʔ]
bor	[bo:ʔʁ]	[bo:ʔɒ̯]	[boɒ̯ʔ]

I do not claim that I, II and III represent unambiguously definable style levels, but I do claim that for each word considered separately, I represents a higher/more distinct pronunciation than II, and similarly for II in relation to III (similar problems are considered in section 3.7 below).

If the phonological length of the vowel in forms like those discussed above (e.g. lav (adj.), bor, tag) is well established, let us then turn to the phonological identity of the post-syllabic segment in question, i.e. to the glide which is the second component of the diphthong, and to [v, ɣ, ʁ]. There are several reasons for preferring a phonological analysis of this post-syllabic segment as [v, ɣ, ʁ] and not as [u̯, i̯, ɒ̯]:

(i) To the same glide, i.e. [u̯], can correspond two different "consonantal" realizations in the same phonetic environment, viz. [v] (e.g. in lov!) and [ɣ] (e.g. in låg); the same "consonant", on the other hand, in a given phonetic environment has only one possible realization as a glide.[1]

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1) The realization of [ɣ] as [i̯] (e.g. in tag) or [u̯] (e.g. in låg) is predictable from the place of articulation of the preceding sound, [ɣ] alternating with [u̯] after back sounds (i.e. back vowels and /r/), and with [i̯] after non-back sounds (i.e. front vowels and /l/). Whereas [ɣ] in conservative standards too is highly dependent on the place of articulation of the preceding sound, a rephonologization has taken place in younger speech, since the two reflexes of older ɣ, viz. [i̯] and [u̯], have merged with the reflexes of the phonemes /j/ and /v/, respectively. In Basbøll 1973a I suggested that the rule which assimilates ɣ to the preceding sound with respect to place of articulation is, in conservative standards, a late phonetic rule

(continued on the next page)

This is one of the clearest arguments for the direction of a phonological process.

(ii) The fullest form (corresponding to the most distinct pronunciation) has a long vowel followed by one of the sounds [v, ɣ, ʁ]. According to Linell's theory of concrete phonology (see further section 4 below), the psychologically central invariant structuring (which might be abbreviated 'PCIS-form') corresponds, roughly, to a maximally distinct (segmentalized) pronunciation, i.e. the PCIS-form would contain a long vowel plus a voiced fricative or [ɣ]. This agrees well with the following two hypotheses: a "stylistic rule" generally has a more conservative form as its input and a more colloquial form as its output, and, secondly, a reduction of a voiced fricative to a glide in the final part of the syllable is a more natural process (and thus more widespread, etc.) than one going in the opposite direction (it goes without saying that these arguments are only suggestive of a certain phonological analysis, they do not *prove* its correctness).

All the non-genuine falling diphthongs considered so far in this paragraph alternated stylistically with a *long* vowel plus one of the phonemes /v, ɣ, r/. Certain sequences of a *short* vowel plus a homosyllabic [ʁ, ɣ] alternate with falling diphthongs as well (whereas a short vowel is never followed by a homosyllabic [v]). The forms with a short vowel plus [ɣ] are

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(continued)
operating on a (continuous) *scale* of places of articulation (i.e. the assimilation is gradual), whereas it is, in younger speech, a *categorial* rule operating in binary features only (making ɣ [+back], i.e. [u̯], or [-back], i.e. [i̯]). It should also be noticed that this ɣ-assimilation rule is dependent on the *r*-colouring of a preceding /a:/ in both younger and more conservative standards: compare *brag* 'crash' [bʁɑ:ʔɣ, bʁɑ:ʔu̯, bʁɑu̯ʔ] with *tag* mentioned in the text.

definitely conservative, just like other forms with [ɣ] (cf. Brink/Lund 1974, p. 39 ff). It should be noted, however, that the sound change [ɣ] ⟶ [i̯] (but not the change [ɣ] ⟶ [u̯]) after short vowels has been carried through even in the most conservative standards (thus nøgle 'key', egn 'region', etc. have diphthongal pronunciations in all varieties of Standard Danish: [nʌi̯lə, ɑi̯ʔn]). Concerning the sequences of short vowel plus a homosyllabic /r/, diphthongization has been carried through except in certain conservative standards, just as other instances of syllable-final /r/ have been vocalized, cf. Brink/Lund 1974, p. 43 ff. (The most salient result of this vocalization may be seen in the cases where [ɒ̯] derives historically from a voiceless [ʁ̥], viz. in the position between a short vowel and one of the phonemes /f, s/ or (written) p, t, k: imperatives like mærk! 'feel!', styrt! 'hurry!' may, in advanced speech, be pronounced with stød: [mæɒ̯ʔg, sdyɒ̯ʔd]; another result of the sound change [ʁ] ⟶ [ɒ̯] is that stød is no longer predictable in syllables historically derived from syllables containing a short vowel + /r/ + /p, t, k, f, s/, compare, for example, ært 'pea', vært 'host', persisk 'Persian' [æɒ̯(ʔ)d, væɒ̯d, pæɒ̯(ʔ)sisg].)

3.3 Falling diphthongs in morphological alternation with vowel-consonant sequences

The diphthongs considered in the main part of the preceding section occurred with both (phonetically) long and short vowels, and they had a more distinct alternative pronunciation with a long vowel plus a voiced fricative (just before closing the paragraph, we quoted certain conservative standards having non-genuine diphthongs in stylistic alternation with short vowel plus voiced fricative). The diphthongs to be treated below, on the other hand, are genuine diphthongs in the sense that the words in question only have diphthongal realizations. Genuine diphthongs in Danish have a short vowel as their first component, both phonetically and concrete-phonologically (cf. below), with the reservation made in section 3.2 above concerning diphthongs historically derived from sequences of vowel plus [ɣ], as well as [ɒ̯]-diphthongs in standards with no postvocalic [ʁ]. In the present section we shall discuss genuine diphthongs in morphological alternation with vowel-consonant sequences.

Consider the related forms stiv, stivne [sdiːʔv, sdiu̯nə] 'stiff, stiffen'. The former word has the alternating pronunciations [sdiːʔu̯, sdiu̯ʔ] in complete agreement with the principles discussed in the preceding section, i.e. [sdiːʔv, sdiːʔu̯, sdiu̯ʔ] are alternate pronunciations of the same word, belonging to decreasing style levels. But the relation between [sdiu̯nə] and [sdiːʔv] is different from that between [sdiu̯ʔ] and [sdiːʔv], since stivne can only be pronounced with a diphthong, never as *[sdi(ː)vnə].

According to Linell's theory of concrete phonology, the PCIS-form of stivne should contain a diphthong, since the word is obligatorily pronounced with a diphthong. But according to more abstract theories of phonology, the simplest analysis would be to posit a long vowel and a fricative as the phonological notation, and operating with a rule of morphological shortening (as distinct from the rule of stylistic shortening mentioned in the preceding section). Whereas stylistic shortening is a variable (optional) rule, morphological shortening is categorial. Thus, stivne may contain phonological /iːv/, and a sequence of short vowel plus /v/ (the output of morphological shortening) is obligatorily realized as a diphthong. Similarly, the paradigm hav, have [hɑu̯, hæːvə] may, within the present analysis, be phonologically /hav - haːvə/, i.e., the apparent diversity in the stem forms is reduced to one of pure vowel quantity alternation, ressembling an apparently simpler paradigm like bad 'bath', bade 'baths' [bað, bæːðə].

All sequences of a (phonologically) long front vowel plus /v/ can be in morphological alternation with a genuine [u̯]-diphthong: stiv 'stiff', stivne 'stiffen';[1] lever 'liver', levret 'clotted'; bæve 'tremble', bævre 'quiver'; have 'seas', hav 'sea'; tyv 'thief', tyvte 'accuse somebody of theft'; øverst 'superior', øvrighed 'authorities' [sdi:ʔv, sdiu̯nə; le:ʔvʌ, leu̯ʁð̞; bɛ:və, bɛu̯ʁʌ; hæ:və, hɑu̯; ty:ʔv, tyu̯də; ø:ʔvʌsd, ǿu̯ʁihẽ:ʔð̞].[2] It is hard to find secure examples of (morphologically) shortened /o:v, u:v/; there is hardly any example of a Danish word ending in /o:v/ which could undergo morphological shortening, whereas the quasi-non-occurrence of words with morphologically shortened /u:v/ (e.g. in luvslidt 'threadbare') may be due to the phonetic fact that the gliding in [uu̯] is difficult to perceive (and thus also to be retained). [æu̯, ɔu̯] apparently only occur as morphologically shortened forms in stylistic alternation with [æ:u̯, ɔ:u̯] and [æ:v,

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1) Compare the neuter form of 'stiff', viz. stift [sdifd], where the stem final /v/ is obligatorily realized as [f] (i.e. devoiced) before the ending /t/ (like in have 'have' [hæ:ʔ, hæ:və], participle haft [hɑfd]), cf. Rischel 1970.

2) I here use the symbol [ʌ] for the unstressed vowel derived from /ər/, although it varies in the whole range [ɑ-ʌ-ɒ], see Basbøll 1974, p. 89 (the footnote). The unstressed [ʌ] is here used as the syllabic counterpart of [ɒ̯] (= [ɒ̥], if you like), cf. that [o] may be used as the syllabic counterpart of [u̯] (= [u̯]), e.g. in mave 'stomach' = Mao [mæo] (the choice of an extreme vowel symbol for the second component of a falling diphthong was defended in section 2.3 above). The symbol [ʌ] is also used for the stressed vowel in godt 'good (neuter)' [gʌd] and the first component of the diphthong [ʌi̯], although the vowel in question is partly rounded, in contradistinction to the IPA-value of this symbol. My use of the symbol [ʌ] is in agreement with the transcription (by Uldall) in Principles of the International Phonetic Association (1949), p. 26, where the description "ʌ=ʌ+ except before r, where the sound is almost ɒ" is found (according to Eli Fischer-Jørgensen (personal communication), Uldall's [ʌ] was less rounded than the common pronunciation today). The use here advocated of the symbol [ʌ] for the stressed vowel is the only acceptable possibility, in my view, if all commutable Danish vowels should be designated by IPA-symbols without diacritics (notice that the symbol [ɔ], also used by Uldall, for the vowel of blå etc., is by now firmly established in IPA transcriptions of Danish). My choice of the symbol [ɒ] for the first component of the diphthong [ɒu̯] is confirmed by the fact that words like bov 'shoulder' [bɒu̯ʔ] may coalesce with words like borg 'castle' when the latter are stylistically shortened: [bɒ:ʔɣ/bɒ:ʔu̯/bɒu̯ʔ].

ɔ:v], e.g. in stavning, lovning.[1]

Examples where a vowel plus [ʁ] is in morphological alternation with a genuine [ɒ̯]-diphthong are less easy to find (cf. the fact that all postvocalic [ʁ]'s have been vocalized, except in rather conservative standards, as mentioned in the preceding section). In rather conservative forms of standard Danish pairs like kære 'dear (definite or plural form)', kærlig 'loving' [kɛ:ʁʌ, kɛᵀɒ̯li] are found (the alternation in question is due to the chronology of the development [ʁ] ⟶ [ɒ̯], which took place earlier before consonants than before vowels). In most varieties of contemporary standard Danish, alternations between a genuine [ɒ̯]-diphthong and a sequence of a vowel plus [ʁ] are restricted to foreign words like klor 'chlorine', klorid 'chloride' [klo:ʔɒ̯/ kloɒ̯ʔ, kloʁi:ʔð/kloʁiðʔ], as pointed out by Rischel (1969, p. 193).

Rischel (ibid. and 1970) also mentioned morphological alternations between genuine diphthongs and sequences of vowels plus [g], e.g. steg '(a) roast', stegt 'roasted' [sdɑi̯ʔ, sdɛgd]. The description of such alternations demands the consideration of phonologically more abstract relationships than those considered in the present paper (Rischel 1970 contains a discussion of such forms).[2]

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1) The word bogstav 'letter (of the alphabet)' may be pronounced [bɔgsdæu̯], however (definite [bɔgsdæ:ʔvð̞/bɔgsdæ:ʔu̯ð̞/bɔgsdæu̯ʔð̞], plural [bɔgsdæ:ʔvʌ/bɔgsdæ:ʔu̯ʌ/bɔgsdæu̯ʔʌ]). The form [bɔgsdæu̯] (in contradistinction to its more regular sideform [bɔ̃gsdæ̃:ʔv/ bɔ̃gsdæ̃:ʔu̯/bɔ̃gsdæ̃u̯ʔ]) is realized, in a stødless syllable, with a phonetically short vowel which has the quality of the long vowel. The obligatory shortness of the vowel as well as the lack of stød may be due to lack of stress, cf. a paradigm like madding 'bite' [maðeŋ], definite [maðeŋʔŋ̍], plural [maðeŋʔʌ].

2) It should also be mentioned that certain words which may be pronounced with [ɑi̯, ʌi̯] have alternate pronunciations with [e:ɣ/e:i̯/ei̯, ø:ɣ/ø:i̯/øi̯], e.g. megen 'much', spøge(lse) 'haunt, ghost'. Other forms with [ɑi̯, ʌi̯], on the other hand, have invariant diphthongal pronunciations, e.g. vej 'road', løg 'onion' [vɑi̯ʔ, lʌi̯ʔ] (which never rhyme with neg 'sheaf', besøg 'visit' [ne:ʔɣ/ne:ʔi̯/nei̯ʔ/ne:ʔ, besø:ʔɣ/besø:ʔi̯/besøi̯ʔ/besø:ʔ]).

3.4 Non-alternating falling diphthongs

The non-alternating falling diphthongs fall into two groups: those which occur as genuine non-alternating diphthongs in a significant number of native words (these diphthongs will be treated in section 3.4.1 below), and those non-alternating diphthongs which occur only in a quite limited number of words which may thus be treated as exceptional (e.g. as violating otherwise descriptively valid redundancy rules). These diphthongs will be considered in section 3.4.2 below.

3.4.1 The core of non-alternating falling diphthongs

The following falling diphthongs occur in a significant number of native Danish words which have no alternating non-diphthongal pronunciations and which are not in morphological alternation with vowel-consonant-sequences (notice that many of the diphthongs listed below are also found in alternation with vowel-consonant-sequences, e.g. lov(e) 'law(s)' [lɒu̯(ə), lɔ:və], but this is, of course, no evidence against what is being said here):

(i) non-alternating [i̯]-diphthongs: [ɑi̯, ʌi̯], e.g. in mig 'me', møg 'muck' [mɑi̯, mʌi̯];

(ii) non-alternating [u̯]-diphthongs: [ɛu̯, ɑu̯, œu̯, ɒu̯], e.g. in evne 'talent', savne '(to) miss', støvle 'boot', ovne 'ovens' [ɛu̯nə, sɑu̯nə, sdœu̯lə, ɒu̯nə];

(iii) non-alternating [ɒ̯]-diphthongs: [iɒ̯, æɒ̯, yɒ̯, Œɒ̯, uɒ̯], e.g. in lirke 'manoeuvre', lærke 'larch', dyrke 'cultivate', dørke 'floors', urter 'herbs' [liɒ̯gə, læɒ̯gə, dyɒ̯gə, dŒɒ̯gə, uɒ̯dʌ].

It can be seen from the above inventory that only a fraction (11 out of about 30, depending on how one counts the number of vowel phonemes) of the possible vowel-glide-sequences belongs to the core of non-alternating falling diphthongs. Furthermore, the missing diphthongs in this inventory do not seem to be accidentally non-occurring, since some general rules can be given to characterize the inventory under discussion here (i.e. the occurring and/or the non-occurring diphthongs of the present inventory constitute a natural class in the phonological sense). The importance of this fact for a possible phonological definition of a diphthong will be taken up in section 4 below.

3.4.2 Residual cases

Apart from the core of non-alternating falling diphthongs in Danish (which is listed in section 3.4.1 above), certain other non-alternating falling diphthongs occur in a small number of words, i.e. they are exceptional non-alternating falling diphthongs. But it is interesting to notice that all the residual [u̯]- and [ɒ̯]-diphthongs[1] listed here do occur, quite regularly, as a result of morphological shortening (cf. section 3.3 above). Morphological shortening is, according to Linell's concrete theory of phonology (cf. section 4 below), an abstract phonological rule; if his assumptions are essentially correct (which seems plausible to me), one would expect the border line between the core of non-alternating falling diphthongs and the residual cases to be psychologically dubious. This agrees with my

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1) The [i̯]-diphthong listed below, i.e. [ui̯], on the other hand, only occurs in the one stem mentioned. This is due to the fact that all sequences of a short vowel plus [i̯] which are created by stylistic or morphological shortening are derived from /V:ɣ̊/-sequences (since the only other source of [i̯], viz. /j/, never occurs after long vowels), and, as already mentioned, ɣ after a back vowel alternates with [u̯], never with [i̯].

suggestion (Basbøll 1973b,p. 119) that phoneme combinations which occur in polymorphemic native words can be introduced in new monomorphemic words without any 'cluster simplification'. This topic will be considered further in section 4 below.

(i) Diphthong in [i̯]: [ui̯]. Only in the stem huj 'hoot' [hui̯].

(ii) Diphthongs in [u̯]: [iu̯, eu̯, yu̯, øu̯]. In the stems: tvivl 'doubt', -lev '(a place name suffix)', peber 'pepper', syv 'seven', -løv '(a place name suffix)' [tviu̯ʔl, -leu̯, peu̯ʌ, syu̯ʔ, -løu̯].

(iii) Diphthongs in [ɒ̯]: [eɒ̯, oɒ̯]. In the stems Per '(a boys' name)', sort 'black', skjorte 'shirt', fjorten 'fourteen', torden 'thunder', hurtig 'fast', mor 'mother', bror 'brother' [peɒ̯, soɒ̯d, sgjoɒ̯də, fjoɒ̯dn̩, toɒ̯dn̩, hoɒ̯di, moɒ̯, bʁoɒ̯].

3.5 Functional arguments for the phonological interpretation of falling diphthongs in Danish

The interpretation of diphthongs is one of the classic problems in structuralist phonology (such as Prague-phonology, Bloomfieldian-phonemics, and glossematics): Are they single phonemes or phoneme combinations? If they are single phonemes, have they long, short, or neutral quantity (in languages with distinctive vowel quantity)? If they are phoneme combinations, is the second part of falling diphthongs phonologically a vowel or a consonant, or something in between? And so on. The arguments to be discussed in the present section are all functional, i.e. purely phonetic facts will not be decisive for the interpretation. Furthermore, morphological and stylistic alternations will be disregarded here, i.e. we consider the non-alternating genuine falling diphthongs only.

It has already been argued above (cf. sections 3.2 and 3.3 in particular) that the (stylistically as well as morphologically) alternating diphthongs should be interpreted phonologically as /VC/-combinations, where /C/ is a voiced oral central continuant, viz. one of the phonemes /v, ɣ, r/.

The following four functional criteria, which apply to alternating as well as non-alternating diphthongs, will be discussed below: commutability (section 3.5.1), occurrence of the stød (section 3.5.2), phonotactics (section 3.5.3), and occurrence of the ending schwa (section 3.5.4). If these criteria do not give the same result, it is hard to see how the ultimate analysis could escape arbitrarity. But if the four criteria mentioned above all point towards the same analysis, and if, furthermore, this analysis concords with the other arguments advanced in the present paper, then the result would seem interesting, at least.

3.5.1 Commutability

The term 'commutability' here refers to the question whether the two components of a diphthong can be commutated independently of each other, and if so, with which other units they can be commutated. Martinet (1939) considered this criterion decisive for the choice between a monophonematic and a biphonematic interpretation. I refer to Martinet's paper and to Fischer-Jørgensen 1956 concerning the 'permissibility' of commutations. I here deviate from Martinet's principles (cf. Martinet 1965, p. 89) by demanding that 'syllabicity' should be kept constant during the commutation, i.e. the number of syllables as well as the location of their peaks should remain unaltered (I thus consider Martinet's commutation [o]:[p] (in French) by means of the example cahot 'bump', cap 'cape' [kao]:[kap], as 'impermissible'; in this pair, the commutation is in fact one of syllable number, just as in pays 'country', paye 'pays' [pɛi]:[pɛj]).

The criterion of commutability thus defined clearly points towards a biphonematic interpretation of the falling diphthongs in Danish. E.g. in [ɑi̯], [ɑ] can be commutated with [ʌ], as in mig 'me' : møg 'muck' [mɑi̯, mʌi̯] (and possibly also with [u̯], cf. the isolated example hej! 'hi!', huj 'hoot, n.' [hɑi̯, hui̯]). It is true for all genuine falling diphthongs that their first component can be commutated with at least one other vowel, and their second component with a number of consonants as well as with at least one other glide (in the case of some of the [ɒ̯]-diphthongs presupposing that the vowel quality be adjusted for 'r-colouring', but this is a general problem with the commutation test, cf. section 4 below). The present criterion thus excludes a monophonematic interpretation and points towards a /VC/-interpretation (although it does not exclude the possibility of the second component belonging to a particular functional class of 'semi-vowels').

3.5.2 Occurrence of the stød

Native Danish monosyllabic words with long vowels always have stød (e.g. gå 'walk', pæn 'nice' [gɔ:ʔ, pɛ:ʔn]).[1] Short vowels in Danish never have stød (e.g. vi 'we', kat 'cat', mand 'man' [vi, kad, manʔ], cf. man! 'conjure!' [mæ:ʔn]).

Danish monosyllables ending in a short vowel followed by a voiced consonant either have stød (on the consonant) (e.g. mand 'man', hal 'hall' [manʔ, halʔ]) or do not have stød (e.g. man 'one', tal 'number' [man, tal]). If the voiced consonant in question is followed by another consonant, the (stressed) monosyllable always has stød (e.g. hals 'neck', vams 'doublet' [halʔs, vɑmʔs]).

Danish monosyllables ending in a diphthong either have stød (e.g.

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1) There is one reservation, however: in younger standards words like stork 'stork', barsk 'tough' may be pronounced with a long stød-less vowel, as [sdɒ:g, bɑ:sg]; the long vowel derives from a short vowel plus a (historically voiceless) /r/, cf. the old pronunciation [sdɒʁ̥g, bɑʁ̥sg], and is thus the result of a 'compensatory lengthening'.

maj 'may, n.', skov 'forest' [maị?, sgɒụ?]) or do not have stød (e.g. mig 'me', tov 'rope' [maị, tɒụ]). If the diphthong is followed by a consonant, the monosyllable always has stød (on the second part of the diphthong) (e.g. egn 'region', skovl 'shovel' [aị?n, sgɒụ?l]). Consequently, Danish diphthongs have stød-conditions like a sequence of short vowel plus a voiced consonant, but quite unlike both long and short vowels.

(If one would, despite the arguments adduced above, persist in claiming that Danish diphthongs phonologically behave like single vowels, one would be forced to recognize a distinction between long-vocalic diphthongs (e.g. in maj, skov) and short-vocalic diphthongs (e.g. in mig, tov), a distinction which could only manifest itself in positions where stød is allowed, and, furthermore, that this alleged quantity distinction could never be manifested as such, but only as a distinction in stød. Although a phonological quantity distinction under certain conditions can be realized as a stød-distinction (e.g. ud 'out', bud 'messenger' [uð?, buð], cf. Rischel 1969, p. 183 f), the postulated phonological vowel length in e.g. ud can be manifested under other conditions, e.g. in more distinct pronunciations ([u:?ð]) and in forms with suffix (ude [u:ðə]), in contradistinction to the alleged vowel length in maj, skov etc. which can never be manifested. And, furthermore, if e.g. travl 'busy' [tʁaụ?l] should contain a long vowel phoneme, it is hard to figure out a plausible analysis of brav 'brave' [bʁa:?v/bʁa:?ụ/bʁaụ?], in distinction to rav 'amber' [ʁaụ].)

3.5.3 Phonotactics

The phonotactics of Danish diphthongs deviates very much from the phonotactics of the short vowels. For example, a short vowel can be followed by two voiced consonants, e.g. halm 'straw', elg 'elk' [hal?m, ɛl?ɣ], whereas a falling diphthong can be followed by at most one homosyllabic voiced consonant (thus words ending in e.g. *[-ɑu̯(ʔ)lm, -æɒ̯l(ʔ)ɣ] are systematically non-occurring).

The phonotactics of long vowels is more like the phonotactics of diphthongs. But these phonotactic similarities are such as apply also to sequences of a short vowel plus a voiced consonant (e.g. the very restricted inventory of following consonant clusters). We must therefore look for a phonotactic criterion distinguishing between long vowels and sequences of a short vowel plus a voiced consonant, and then see in which of these groups the falling diphthongs belong.

A possible candidate for such a phonotactic criterion is the possibility of occurring before the glide [ɒ̯]. All long vowels occur before [ɒ̯], whereas the occurrence of falling diphthongs before [ɒ̯] is, at best, dubious (the non-occurrence of [ɒ̯]-diphthongs before [ɒ̯] does not, of course, show anything, since it follows from the general impermissibility of identical adjacent homosyllabic segments). Possible counterexamples to the claim advanced here are a few words like <u>sejr</u> 'victory', <u>navr</u> 'common maple', <u>tøjr</u> 'tether'. These words are normally pronounced as bisyllabic, i.e. as [sɑi̯ʔʌ, nɑu̯ʔʌ, tʌi̯ʔʌ], thus rhyming with <u>bajer</u> '(bottle of) lager', <u>tau'er</u> '(plural of Greek letter name)' [bɑi̯ʔʌ, tɑu̯ʔʌ], and coalescing with <u>tøjer</u> 'cloths' [tʌi̯ʔʌ], respectively. But it is an option to certain speakers of Standard Danish to distinguish between monosyllabic and bisyllabic pronunciation in the cases just mentioned, so that e.g. <u>tøjr</u> may be pronounced as a monosyllable and thus be in commutation with <u>tøjer</u>. Nevertheless, I think the argument given above, in favour of considering, on phonotactic grounds, the falling diphthongs as /VC/-combinations rather than long vowels, is valid for all varieties of Standard Danish, for the following reason: After long vowel phonemes, there is a stable opposition between /r/ (manifested as [ɒ̯]) and /ər/ (manifested as [ʌ]), e.g. <u>ser</u> 'sees', <u>seer</u> 'seer (prophet)'; <u>ror</u> 'rows', <u>roer</u> 'rower' [se:ʔɒ̯, se:ʔʌ; ʁo:ʔɒ̯, ʁo:ʔʌ]. After sequences of a short vowel plus a voiced consonant, on the other hand, there is in some cases a vacillation between /r/ and /ər/ (e.g. in imperatives like hædr!, bladr! which may be pronounced either mono- or bisyllabically); this vacillation just mirrors the vacillation in imperatives like sejr! 'win!', flagr! 'flutter!', which may also be pronounced either mono- or bisyllabically, just like the situation with sejr, tøjr and navr in those standards which have the option of a monosyllabic pronunciation of such forms.[1] To sum up: the falling diphthongs behave phonotactically as sequences of a short vowel phoneme plus a vowel-adjacent (voiced) consonant.

Another argument is the following: Presupposing that 'syllabicity' is kept unaltered during the commutation (see section 3.5.1 above), the second component of the diphthong in a case like mig 'me' [mɑi̯] is commutable with a large number of consonants and with the glide [u̯]. If the glides are interpreted as vowel phonemes, a short vowel phoneme like /a/ could be followed by either a consonant (except /v/ and /r/, among others), or by one of the vowel phonemes u, ɒ, i (manifested as a glide). But if instead we consider the glides as manifestations of consonant phonemes, a short vowel phoneme like /a/ can be followed by consonants but not by vowels. This principle is much more general (cf. Levin 1974, p. 58).

Phonotactics also gives a hint as to which consonants the phonetic glides [i̯ u̯ ɒ̯] may be identified with phonologically (the initial [i̯] and the final [i̯] can be immediately identified phonologically):

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1) Cf. the vacillation between /l/ and /əl/ after nasals in imperatives, so that handl! 'trade!', skraml! 'clatter!' may coalesce, but need not do so, with the nouns handel 'trade', skrammel 'rubbish' (if the distinction is maintained, it is by means of "syllabicity", except in the rare cases where a [ə] is pronounced before /l/).

We noticed in section 3.2 above that [v] and [u̯] are free variants after long vowels (with different stylistic effect). After short vowels [u̯] occurs, but not [v], whereas [v] occurs in the initial part of the syllable, in contradistinction to [u̯]. According to normal phonological practice, [v] and [u̯] may thus be considered manifestations of the same consonant phoneme, i.e. /v/.

In the final part of the syllable, [ʁ] and [ɒ̯] occur as variants (under different conditions in different dialectal, sociolectal and stylistic standards). In the initial part of the syllable only [ʁ] occurs, and [ʁ] and [ɒ̯] may therefore be considered manifestations of the same consonant phoneme, i.e. /r/, according to normal principles of phonological analysis.

3.5.4 The ending schwa

Definite and plural form of adjectives is normally constructed by addition of the ending schwa (e.g. gul (indef. sg.) 'yellow', gule (def. or pl.) [gu:ʔl, gu:lə]). Also infinitives generally end in schwa (e.g. spise 'eat' (inf.), spis! [sbi:sə, sbi:ʔs]). Certain adjectives in their definite and plural form, as well as certain infinitives, do not end in schwa, however, but in a stressed vowel (e.g. blå 'blue' (all forms), gå 'walk' (inf. and imp.) [blɔ:ʔ, gɔ:ʔ]).

According to Martinet (1937, chapter 4), who included such forms in his treatment of the Danish diphthongs, the rule is that stems ending in a consonant take schwa, whereas stems ending in a vowel take zero instead of schwa.

Martinet's formulation only applies to non-narrow vowels, however (and not to the verbs ae 'caress' [æ:ə], bejae 'say yes to' [bejǽ:ʔə]). The verbs tie 'keep silent' and true 'threaten', for example, have infinitives ending in schwa, just like the adjective fri in declined form most often takes schwa. Certain other stems ending in a narrow vowel have vacillation (e.g.

ny/nye 'new' (def. or pl.) [ny:ʔ, ny:ə]), whereas still others never take schwa (e.g. si 'strain' (inf. and imp.), sy 'sew' (inf. and imp.), kry 'perky' (all forms) [si:ʔ, sy:ʔ, kʁy:ʔ]). The correct generalization is thus weaker than Martinet's, viz.: stems ending in a consonant always take schwa, whereas stems ending in a vowel normally do not take schwa (where certain stems ending in a narrow vowel constitute exceptions to the normal case).

All stems terminating in a diphthong take schwa as ending in the relevant grammatical forms, e.g. sove 'sleep' (inf.), blege 'pale' (def. or pl.) [sɒu̯ə, blɑi̯ə] (of course, schwa in such forms can assimilate to neighbouring sonorants, just like all other schwas, whatever their origin: e.g. sove can be pronounced [sɒo] and the like, but the lack of stød as well as the two-peak-syllabicity clearly show that the form is bisyllabic, in casu constructed from the monosyllabic vowel stem plus the ending schwa; cf. the first footnote to section 3.7 below).

3.6 Falling diphthongs occurring after /r/

Up to this point, we excluded diphthongs occurring after /r/ from consideration, since they often begin with vowel qualities which are different from those of the first part of diphthongs not occurring after /r/. We are therefore obliged to investigate whether our results, which were obtained from an examination of diphthongs not occurring after /r/, account also for the diphthongs occurring after /r/, together with the independently needed principles for "r-colouring" (for a summary of these, see Basbøll 1972b, p. 202 ff).

Since initial [ʁ] in Danish does not occur before the glide [i̯] (except in very fast speech where a prevocalic /i/ may be desyllabified), all Danish diphthongs which may be /r/-coloured are falling. As for the non-genuine falling diphthongs occurring after /r/ (cf. section 3.2 above), the quality of their first component is identical to the normal r-coloured quality of the long vowel with which it alternates: e.g. the word røv! 'rob!' has a lowered /ø:/ in both non-diphthongal and diphthongal pronunciations, cf. the word rød 'red' [ʁø˕:ʔv, ʁø˕:ʔu̯, ʁø˕u̯ʔ; ʁø˕:ʔð, ʁø˕ðʔ] (/ø:/, as well as other vowels, may be r-coloured, i.e. lowered and/or retracted, to different degrees in different standards).

r-colouring in cases of morphological shortening (cf. section 3.3 above) follows a similar pattern: the /e:, e/ of brev 'letter', brevpakke 'small packet' is r-coloured just like the /e:, e/ of bred 'broad', bredskuldret 'broad-shouldered' [bʁe˕:ʔv, bʁe˕:ʔu̯, bʁe˕u̯ʔ; bʁé˕u̯pɑ̀gə; bʁe˕:ʔð, bʁé˕ðsgùl(ʔ)ʁð̩]. The conclusion is that (the first component of) alternating (genuine as well as non-genuine) diphthongs undergo(es) r-colouring (i.e. lowering and/or retraction due to an /r/, which in this case precedes the diphthong) according to the same general principles as monophthongs.

We must now proceed to the non-alternating falling diphthongs occurring after /r/. Since these diphthongs do not alternate with any other segment(s), we do not know a priori which vowels their first components are to be identified with phonologically, and therefore we ignore, a priori, whether the general principles of r-colouring suffice to account for the inventory of non-alternating diphthongs occurring after /r/. The core of this inventory (cf. section 3.4.1 above) is as follows:

(i) [i̯]-diphthongs after /r/: [ɑi̯, ʌi̯]. Thus regn 'rain', røg 'smoke' [ʁɑi̯ʔn, ʁʌi̯ʔ] rhyme with degn 'parish clerk', støj 'noise' [dɑi̯ʔn, sdʌi̯ʔ]. This agrees well with the notation of the first part of these diphthongs as low back vowels, since monophthongal low back vowels like [ɑ, ʌ] generally are not much r-coloured (from an auditory point of view): ram 'acrid', rom 'rhum' [ʁɑmʔ, ʁʌmʔ] rhyme with tam 'tame', tom 'empty' [tɑm?, tʌm?] (cf. the table below).[1] Ege's notation [œ̹] (equivalent to our symbol [Œ]) for the non-r-coloured diphthong (1965, p. 26), on the other hand, is exceptional in two respects: this will be the only context where [œ̹] is not a result of r-colouring, and [œ̹] before [i̯] will be the only non-high front vowel which is not r-coloured (arguments like the preceding are not decisive to a purely phonetic notation, of course; but Ege himself asks whether the first part of the diphthong may be 'heard' as [œ̹] (instead of [ɒ̹]) "by account of intuitive preconceptions of morphophonemic patterns (conjugation type: [by:ðə ~ bø:?ð] paralleling type: [ly:və ~ lœ̹j?]), or phonotactic phonemic patterns ([j] does not occur after other back vocoids either), maybe even furthered by etymology or spelling!" (ibid.)

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1) The notation [ɑi̯, ʌi̯] is also in accordance with another general principle of Danish, viz. that glides can only be dropped after homorganic vowels, presupposing that vowels be classified with respect to place of articulation according to their principal narrowing above the glottis, i.e. [ɑ, ɒ] are pharyngeal (and not velar) vowels. Thus [ɒ̯] is generally dropped after the pharyngeal vowels [ɑ, ɒ], e.g. har 'has', går 'walks' [hɑ:?, gɒ:?] but is always retained after palatal vowels like [i, æ], e.g. ir 'verdigris', bær 'berry' [iɒ̯, bæɒ̯] and after the velar vowels [u, o], e.g. sur 'sour', mor 'mother' [su:?ɒ̯/suɒ̯?, moɒ̯]. Similarly, [u̯] can be dropped after the velar vowels [u, o], e.g. luv 'nap', tog 'took' [lu:?v/lu:?, to:?ɣ/to:?u̯/tou̯?/to:?], but not after palatal vowels like [i,ɛ], e.g. stivne 'stiffen', evne 'talent' [sdiu̯nə, ɛu̯nə], nor after the pharyngeal vowels [ɑ, ɒ], e.g. hav 'sea', hov 'hoof' [hɑu̯, hɒu̯?]. Finally, [i̯] can be dropped after palatal vowels like [i, æ], e.g. vig 'cove', tag 'roof' [vi:?, tæ:?ɣ/tæ:?i̯/tæi̯?/tæ:?], but is always retained after velar vowels, e.g. huj [hui̯] (except before [ð̞] in advanced speech, e.g. øjet, meget [ɒ:ð̞, mɑ:ð̞], cf. Brink/Lund 1974, p. 38 f). The nice symmetry of this system is retained with the notation [ɑi̯, ʌi̯], i.e. with an analysis of the first component of these two [i̯]-diphthongs as back vowels. (The fact that glides may be dropped only after homorganic vowels might be explained by a general difficulty in perceiving just such glidings.)

(ii) [u̯]-diphthongs after /r/: [ɑu̯, ɒu̯, æu̯, Œu̯]; e.g. ravn 'raven', rogn 'roe' rhyme with savn 'want', sogn 'parish' [ʁɑu̯ʔn, ʁɒu̯ʔn; sɑu̯ʔn, sɒu̯ʔn]. This notation agrees with one of the general principles of r-colouring, viz. that low back vowels are not much coloured by a preceding /r/ (cf. above). But words like revne 'crack', vrøvle '(to) drivel', on the other hand, show a considerable r-colouring (roughly, lowering by "one degree"), as compared to the non-r-coloured diphthongs in e.g. levne 'leave', støvle 'boot' [ʁæu̯nə, vʁŒu̯lə; lɛu̯nə, sdœu̯lə]. This agrees well with another general principle of r-colouring, viz. that low front vowels are considerably coloured by a preceding /r/.[1] ('Rhyme' is taken here in its auditory sense.)

(iii) [ɐ̯]-diphthongs after /r/. Since [ɐ̯] is a syllable-final manifestation of /r/, the genuine [ɐ̯]-diphthongs help define the notion of "r-colouring". The diphthongs to be considered in this paragraph are those with the structure /rVr/ where /V/ is a short vowel. However, there seem to be no genuine non-alternating forms with /rVr/.[2]

The results obtained in this section are summarized in the table below. The sign ∼ means 'rhymes with', ≀ means 'does not rhyme with'. These designations are only used as approximations, in the auditory sense. The pronunciations indicated in the table are based upon Advanced Standard Copenhagen speech.

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1) An isolated form with [ɛu̯] after /r/ may be heard, however, viz. rev (n.) 'reef' [ʁæu̯, ʁɛu̯] (Hansen 1962, p. 214). The pronunciation [ʁɛu̯] may be classified as a lexical exception, just like peber [peu̯ʌ], cf. section 3.4.2 above. Thus, I consider [ʁɛu̯] as an instance of the regularly r-coloured diphthong /ev/ (which does not belong to the core of non-alternating diphthongs in Danish, cf. section 3.4 above), and not as a manifestation of the /ɛv/-diphthong, which would then, quite exceptionally, not be subjected to r-colouring.

2) There only seems to be one morphologically shortened example with this structure, viz. rørlig 'movable' [ʁŒɐ̯li], rhyming with gørlig 'possible (literally: "do-able")'. rørlig thus contains a genuine alternating diphthong, cf. røre 'move' [ʁœːʌ, ʁŒːʌ] (also with vowel shades in between [œ] and [Œ]), but since the example is isolated, it can hardly be considered part of the core of falling diphthongs occurring after /r/.

Diphthongs	not occurring after /r/		occurring after /r/		Monophthongal parallels
[i̯]-diphthongs	[ɑi̯] [dɑi̯ʔn] degn	[ʌi̯] [sdʌi̯ʔ] støj	[ɑi̯] [ʁɑi̯ʔn] regn	[ʌi̯] [ʁʌi̯ʔ] røg	[tɑmʔ, tʌmʔ]~[ʁɑmʔ, ʁʌmʔ][1] tam, tom ram, rom
non-alternating [u̯]-diphthongs with front vowel	[ɛu̯] [ɛu̯nə] evne	[œu̯] [sdœu̯lə] støvle	[æu̯] [ʁæu̯nə] revne	[Œu̯] [vʁŒu̯lə] vrøvle	[ɛnə, kœnə] ≀ [ʁænə, ʁŒnə] ende, kønne rende, rønne
non-alternating [u̯]-diphthongs with back vowel	[ɑu̯] [hɑu̯] hav	[ɒu̯] [hɒu̯ʔ] hov	[ɑu̯] [ʁɑu̯] rav	[ɒu̯] [ʁɒu̯] rov	[tɑmʔ, sgɒːʔ]~[ʁɑmʔ, sgʁɒːʔ][2] tam, skår ram, skrår
alternating [u̯]-diphthongs with high vowel	[iu̯] [iu̯ʁi] ivrig	[yu̯] [tyu̯də] tyvte	[iu̯] [ʁiu̯neŋ] rivning	[yu̯] [kʁyu̯ʔ] "kryb!"[3]	[kidʌ, dydʌ]~[ʁidʌ, ʁydʌ] kitter, dytter Ritter, rytter
alternating [u̯]-diphthongs with high-mid vowel	[eu̯] [leu̯ʁð̩] levret	[øu̯] [løu̯fàlʔ] løvfald	[ɛu̯] [bʁɛ́u̯pāgə] brevpakke	[œu̯] [pʁœu̯neŋ] prøvning	[med, mød] ≀ [bʁɛd, ʁœd] midt, mødt bredt, rødt

3.7 "b-diphthongs"

A few words should be said about a type of non-genuine falling diphthongs which has been disregarded up to this point, viz. the [u̯]-diphthongs which are in stylistic alternation with sequences of a long vowel plus the stop [b], e.g. in the words pibe 'pipe', kneb 'pinched', sæbe 'soap', tabe 'lose', krybe 'crawl', løbe 'run', råbe 'cry' [pi:bə/pi(·)u, kne:ʔb/kneu̯ʔ, sɛ:bə/sɛ(·)u, tæ:bə/tæ(·)u, kʁy:bə/kʁy(·)u, lø:bə/lø(·)u, ʁɔ:bə/ʁɔ(·)u].[1] We chose to consider these diphthongs, not

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(footnotes to the table:)

1) In more conservative standards where /a/ in tam, etc., is not as retracted as in younger speech, and where tam ≷ ram, the pronunciation of /a/ before [i̯] is similar to the pronunciation of /a/ before labials or velars, according to the standard, whereas /a/ before [u̯] is more lowered and retracted (so that this latter /a/ can be identical to the r-coloured /a/ also in conservative standards).

2) In this case only, the monophthongal parallels are long vowels. I argue in Basbøll 1972b (p. 202 ff) that vowel quantity is insignificant for the prediction whether a given vowel is r-coloured or not. (The best monophthongal parallel would be tom∼rom quoted above.)

3) The pronunciation with [u̯] instead of [b] in the word kryb! 'crawl!' is stylistically conditioned (restricted to definitely colloquial etc. speech), as opposed to the other examples, except prøvning, which have genuine, viz. non-alternating or morphologically conditioned, diphthongs.

(footnote to this page:)

1) ə can be assimilated to a preceding [u̯] just as it can be assimilated to other non-syllabic sonorants; the result of this assimilation is here rendered as [u], although the transcription [o] would in many cases, particularly after low vowels, be more exact (phonetically). I use the terms 'b-diphthongs', diphthongization, etc., also covering such assimilated forms, although they may be considered not to be phonetic diphthongs, strictly speaking, since the gliding is partitioned over two syllables (the location of the syllable boundary may be decisive for the classification of such forms, but I shall leave this problem here since it is non-pertinent for my purpose - and, at any rate, there are a lot of 'b-diphthongs' which are undoubtedly diphthongs in any phonetic sense of the term).

together with the other non-genuine falling diphthongs in section 3.2 above, but separately, in the present section, since they are deviant from those other diphthongs in the following respects:

(i) Words with a long vowel plus [b] may be in stylistic alternation (variation) only with forms containing a falling diphthong, never with forms containing a vowel plus a voiced fricative, e.g. [v] or [β] (the sound [β] does not occur in Standard Danish at all). The other non-genuine diphthongs, on the other hand, alternate stylistically with sequences of a long vowel plus a voiced fricative (e.g. <u>løv</u> 'foliage' [lø:ʔv/lø:ʔu̯/løu̯ʔ]), never with a vowel plus a stop (but <u>genuine</u> falling diphthongs can be in <u>morphological</u> alternation with vowel-stop-sequences, e.g. <u>spøge</u> 'joke (inf.)', <u>spøgt</u> 'joked (ptc.)' [sbø:ɣə/sbø(:)i̯ə, sbøgd], cf. section 3.3 above).

(ii) Not all words with a long vowel followed by [b] have [u̯]-diphthongs as alternating pronunciations, e.g. <u>læbe</u> 'lip', <u>håbe</u> 'hope' are always pronounced [lɛ:bə, hɔ:bə], cf. the alternating pronunciations of <u>sæbe</u>, <u>råbe</u> mentioned above. Since no general principle can be given predicting which vowel-b-sequences have alternating pronunciations with [u̯]-diphthongs, and which do not, the distinction between these two groups of vowel-b-words must be "lexically" (diacritically) marked. All words with long vowel plus /v, ɣ, r/, on the other hand, have alternating pronunciations with falling diphthongs (under certain <u>stylistic</u> conditions etc., but presupposing no lexical marking).

(iii) b-diphthongization in Standard Danish does not occur in higher styles (in certain regional varieties of the language, b-diphthongization is more widespread, both as regards the number of words which can undergo it, and as regards the frequency with which they undergo it). Thus, in Standard Danish there exist certain levels of style in which "b-words" are never diphthongized, as opposed to /v, ɣ, r/-words.

The three differences just pointed out do not, of course, show that b-diphthongization is unrelated to the other cases of diphthongization which have been discussed throughout this paper. On the contrary, we shall try in the present section to investigate the possibility that b-diphthongization can be accounted for according to similar principles as those which have already been suggested for the other diphthongs.

First of all, there must be a lexical distinction between b-words which are sometimes diphthongized (e.g. pibe, sæbe, råbe) and those which are never diphthongized (e.g. vibe, 'lapwing', læbe, håbe). One way to mark this difference phonologically is through a notation with /b/ in the former case (e.g. /pi:bə, sɛ:bə, rɔ:bə/) and with /p/ in the latter (e.g. /vi:pə, lɛ:pə, hɔ:pə/), cf. Holt 1949. Accordingly, /V:b/-sequences may diphthongize, as opposed to /V:p/-sequences. This agrees well with the standard analysis of [ɣ] as derived from /g/ (remember that [ɣ] can be vocalized to [i̯] or [u̯]), whereas /Vk/-sequences never are turned into diphthongs.[1] However, this notation is hardly much more than a codification of the different behaviour of the two types of b-words.

We can thus, descriptively, posit a rule b ⟶ u̯ (which only applies to certain "b-words", as mentioned above). The rule applies only to words which in their distinct pronunciation have a long vowel plus [b]. Diphthongization does not occur if the vowel is u (grube 'pit', kube 'cube', strube 'larynx'; Hansen 1956, p. 51), and hardly if it is o (oktober

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1) This interpretation does not cover varieties of Standard Danish where words like rype 'grouse' can be pronounced with an aspirated stop [ʁy:pə], but such forms seem to be very rare and unsystematically occurring, and, accordingly, I shall disregard the possibility of such pronunciations here.

'october', <u>sober</u> 'sober', <u>knob</u> 'knot', but possibly in <u>hoben</u> 'heap'; ibid.). These "exceptions" may be related to the fact that the sequences [u(:)u̯, o(:)u̯] generally do not occur (cf. section 3.3 above); if /u:b, o:b/-sequences were diphthongized, their phonological /b/ might coalesce with zero, as well as with /v, ɣ/.

It is clear that the direction of the rule is b ⟶ u̯ in such words (rather than the reverse, i.e. that /u̯/ or the segment normally underlying [u̯], viz. /v/, should be pronounced [b] by a rule u̯ ⟶ b or v ⟶ b):

(i) If [løːbə] were a derived form, and the phonological form contained /u̯/ or /v/, then we would expect, in agreement with the normal behaviour of optional rules, that the most distinct pronunciation be the one with [u̯] or [v], which contradicts the facts (the pronunciation with [v] is hardly possible at all in Standard Danish). (ii) Under certain conditions a postvocalic [b] never alternates with [u̯], although all lexical as well as stylistic conditions seem fulfilled: e.g. <u>tabt</u>, <u>råbt</u> are never, in Standard Danish, diphthongized: [tɑbd, ʁʌbd; *tɑu̯d, *ʁʌu̯d]; this suggests that the plosive be primary and the glide derived, see further below.

The optional manifestation rule b ⟶ u̯ is unparalleled in Standard Danish. The possibility might therefore be considered that the effect of this rule be obtained by dissolving it into two other rules, viz:

b ⟶ β and β ⟶ u̯.

The former rule bears evident similarities to the rules of "consonant gradation" proposed and discussed, e.g., by Uldall 1936, Hjelmslev 1951 and Rischel 1970, viz.: d ⟶ ð and g ⟶ ɣ. The latter rule is reminding of the other diphthongization rules discussed in this paper, viz.:

v ⟶ u̯; ɣ ⟶ i̯, u̯; r ⟶ ɒ̯.

Below, we shall therefore consider the possibility that the rule b ⟶ u̯ is superfluous, since it can be substituted by two other rules which may be integrated into two independently needed rules, viz. consonant gradation and diphthongization, which will be considered in turn.

Ad consonant gradation: The central condition for the vocalization of /b/ is identical to the condition for the rules d ⟶ ð and g ⟶ ɣ, viz. that the consonants in question occur in the final part of the (phonological) syllable (thus words like nabo 'neighbour', Saba 'Sheba' are never diphthongized: [næ:bo, sæ:ba; *næ(:)u̯o, *sæ(:)u̯a], cf. the pronunciation of words like soda 'soda', Ida '(a name)' [so:da, i:da; *so:ða, *i:ða]). Furthermore, the class of /b d g/ is more natural than the class of /d g/ alone, and an extension of the rule of consonant gradation to cover /b/ too will thus be a generalization. On the other hand, the rule b ⟶ β is variable, whereas d ⟶ ð and g ⟶ ɣ are categorial. But there exists a good argument, I think, to the effect that the generalization of consonant gradation to include b ⟶ β is, in fact, linguistically significant: Under certain conditions, viz. before a voiceless consonant (not preceded by a strong grammatical boundary: ≠, cf. my paper on Grammatical Boundaries in this vol. p. 126 ff),a syllable-final /g/ is never realized [ɣ] (nor [i̯, u̯]), e.g. kogt 'cooked', bagt 'baked' [kʌgd, bɑgd; *kʌu̯d, *bɑu̯d] (a /d/ is deleted under such conditions, e.g. mødt 'met', hvidt 'white (neuter)' [mød, vid; *møðd, *viðd] - the sequence [ðd] is not phonotactically excluded, as opposed to [dd], e.g. perfidt 'perfid (neuter)' [pæɐ̯fi:ʔðd/pæɐ̯fiðʔd]). Under exactly the same conditions, a syllable-final /b/ can never be manifested by [u̯] although all stylistic and lexical conditions seem fulfilled: e.g. tabt(e) 'lost', råbt(e) 'cried' (disyllabic forms are preterites, monosyllabic forms are participles) [tɑbd(ə), ʁʌbd(ə); *tɑu̯d(ə), *ʁʌu̯d(ə)]. Thus, the rule g ⟶ ɣ and the vocalization of b have identical contexts where they never apply, and this may be taken as a suggestion that these two rules are only parts of a more general process.

Ad diphthongization: Since [β] will be a member of any natural phonetic class which includes both [v] and [u̯], it should not create any complications at all to incorporate the change β ⟶ u̯ into the general process of vocalization (one of whose results is [v] ⟶ [u̯]). It does appear to be a complication, however, that the process [β] ⟶ [u̯] seems to be obligatory (since no phonetic [β]'s appear on the surface), whereas some other instances of vocalization (or diphthongization) are only optional (thus forms like løve need not be diphthongized: [lø:və]).

I do not think, however, that this fact invalidates the incorporation of [β] ⟶ [u̯] into the vocalization rule, nor that it motivates a special restriction on this rule: It is clear that there are speech style levels in which words with phonological /V:v/ (like løve) are diphthongized, whereas all words with /V:b/ (like løbe) are pronounced with [b]. The opposite situation, i.e. speech styles which have b-diphthongs but where all /V:v/-words are pronounced with [v], do not exist, to my knowledge. Thus, a stylistic restriction is demanded, in any case, to the effect that b-vocalization is situated on a lower level of the speech level hierarchy than v-vocalization. If the rule b ⟶ u̯ is split up, as proposed here, into b ⟶ β and β ⟶ u̯, then the stylistic restriction (which, as noted, is needed anyhow) will guarantee that at speech levels where the rule b ⟶ β applies, the rule β ⟶ u̯ will apply also.

To give a little more substance to the treatment of optional rules suggested here, consider the rule of stylistic shortening (responsible for shortening the vowel of sød 'sweet' [sø:ʔð, søðʔ] etc.). If there are speech styles in which long vowels are not shortened before [ð] (e.g. båd 'boat' [bɔ:ʔð]), but in which words with /V:v/ may be diphthongized (e.g. lov! [lɔ:ʔu̯], whereas the opposite situation seems to be non occurring, then stylistic shortening should be situated below v-vocalization in the stylistic hierarchy. This placement would be sufficient to account for the non-existence of stylistically shortened forms with [v] instead of [u̯] (e.g. *[løvə]). But it is not easy to determine the relation between v-vocalization and stylistic shortening in this respect.

Stylistic shortening is evidently situated higher up in the stylistic hierarchy than b-diphthongization, since there is hardly any doubt that long vowels can be stylistically shortened, e.g. before [ð], in style levels in which all words with /V:b/ are pronounced with the stop [b]. Now, this relative placement of stylistic shortening and b-diphthongization makes an interesting prediction: b-diphthongized forms should be stylistically shortened. This appears always to be true when the vocalized /b/ is word-final (e.g. <u>løb</u>! [lø:ʔb/løu̯ʔ]), and concerning the vocalization of /b/ in the context /V__ə/, the prediction agrees well with the following quotations: "Pronunciations with [u] for [b̥] are strictly colloquial and in many cases distinctly substandard or dialectal. In my speech they are normally accompanied by shortness of the preceding vowel, which is not necessarily true of forms with [u] alternating with [v] (or [ɣ]), cp. [kniu:] (∾[kni:bə]) 'be difficult for somebody' vs. [kni:u] (∾[kni:və]) 'knives'" (Rischel 1970, p. 469); and "Those who use u in both cases [i.e. in both <u>løve</u> and <u>løbe</u>, etc.; HB] appear (according to Eli Fischer-Jørgensen) to differentiate by means of quantity: longer vowel before original v than before original b" (Hansen 1956, p. 70). Rischel's example is very well suited to show the difference, since the vowel is high (in which case the tendency towards shortening is very pronounced) and the quality of the short and long vowel is identical. In forms like <u>tabe</u>, <u>råbe</u>, on the other hand, the vowel quality (viz. [æ, ɔ]) in itself indicates the phonological vowel length, and the auditory length is not easy to agree on.

According to the account just given, the occurrence of stød should not be influenced by the diphthongization of a /V:b/-word, and generally, it is not: skab 'cupboard' [sgæ:ʔb, sgæu̯ʔ]. In a pronunciation of skib 'ship' as [sgiu̯], on the other hand, we must recognize the existence of lexical doublets, cf. the alternative pronunciations [sgi:ʔb/sgiu̯ʔ]. (Lexical doublets with long and short vowel phonemes, and occurring with and without stød, respectively, in monosyllabic forms, are found in slag [slæ:ʔɣ/slæ:ʔi̯/slæi̯ʔ, slɑɣ/slɑu̯], stød [sdø:ʔð/sdøðʔ, sdøð], and in many other words. Examples like slag are particularly informative, since they demonstrate an obvious difference in vowel quality of the lexical doublets, clearly indicating a phonologically long and short vowel, respectively.)

4. Conclusion: can 'diphthong' in any sense be considered a phonologically relevant concept in Danish?

In the preceding section a number of arguments were advanced to the effect that the Danish diphthongs phonologically function as homosyllabic /VC/-combinations, where /C/ behaves like a voiced non-lateral continuant (voiced since it can receive the stød, and a central oral because the preceding vowel generally participates in vowel length alternations or -neutralizations, cf. section 2.2.2 above). Specific arguments pointed towards a phonemic identification of /C/ with one of the phonemes /v/, /r/, /j/, maybe /ɣ/ (where /ɣ/ may well be derived from /g/) and possibly partly /b/. If a 'phonological (or phonemic, functional) diphthong' is defined in a parallel fashion with a phonetic diphthong, viz. as a homosyllabic sequence of two vowel phonemes, the phonetic diphthongs in Danish therefore cannot be considered phonological diphthongs too. But can any other sense be assigned to the term 'phonological diphthong' so that it becomes a functionally relevant concept in Danish phonology?

If a phonological diphthong can only be defined as a sequence of one or more phonemes which is manifested by a phonetic diphthong, this is tantamount to denying the phonological relevancy of the term 'diphthong'. If we consider the falling and rising diphthongs in Danish together, this definition seems to be the only possibility, i.e. the class of all phonetic diphthongs in Danish is not a natural one in any phonological sense.

If we consider only the class of all "genuine" falling diphthongs in Danish, in the sense discussed in section 3, these diphthongs can be defined phonologically as homosyllabic sequences of a short vowel phoneme plus one of the phonemes /v, r, j/ (and maybe /ɣ/, depending on the variety of Standard Danish used as material as well as on the principles of analysis chosen). The class of consonant phonemes in question constitutes a phonologically natural class. But the very fact that the phonetic diphthongs can be defined, phonologically, in a non-circular manner, i.e. without referring to their manifestation as diphthongs, does not, of course, show that the concept is phonologically relevant. At most, it shows that the class of consonants which can be 'vocalized' is a natural one. We must thus look in quite another direction (cf. Spang-Hanssen 1959).

A phonological syllable in Danish has a vowel phoneme as peak, and zero, one or more consonants in its onset and in its coda. Thus its maximal structure is the following:

$$/C_{i3}C_{i2}C_{i1}V\ C_{f1}C_{f2}C_{f3}\ldots/$$

(i means "initial" and f "final", whereas the numbers indicate distance from the syllabic peak; the number of final consonants depends on which inflected and derived forms are included in the material, but this problem is irrelevant in the present context).

When we consider _any_ homosyllabic sequence of two consonants, either belonging to the onset or to the coda, i.e. /CC/, the paradigma in each consonant position depends on the choice of the other consonant. E.g. if we have chosen /s/ as the first consonant of the sequence /CC/, the other consonant could be /b/, /m/, /l/, etc., but not /r/ or /f/. And if we have chosen /v/ as the second consonant, the first one could be e.g. /d/, /k/ or /s/ (if the sequence is in the onset), but not e.g. /l/, /p/ or /n/; or it could be /l/ or /r/ (if the sequence is in the coda), but not e.g. /t/, /j/ or /m/. The restrictions of choice are much heavier if we know the position of the consonant sequence in the syllable, e.g. if the sequence is given as /$C_{i3}C_{i2}$/ or /$C_{f1}C_{f2}$/, etc. (The actual restrictions can easily be constructed from the existing phonotactic studies of Danish, such as Vestergaard 1968 and Basbøll 1973b.) It should be emphasized that the relevant restrictions are all _structural_, i.e. accidentally missing clusters should be considered part of the material (for some discussion of connected problems, see Fischer-Jørgensen 1952).

If we consider the sequence /CV/, the situation is quite different: the choice of a specific consonant does not restrict the possibility of choice of the vowel, and vice versa. It should be mentioned here that we speak about phonemes, not allophones, in this context. If, for example, we choose the consonant phoneme /r/, the following vowel will be realized as an "r-coloured" allophone, i.e. as a lower and more retracted vowel in comparison to its non-r-coloured counterpart (and the situation with /r/ is only one particularly striking instance of a quite general phenomenon). The only apparent example in Danish where a possible initial consonant cannot be freely combined with a possible vowel phoneme is /j/ plus /i/. This restriction (i.e. the non-occurrence of /ji/) does not seem to be a structural one, however, since words like _sjippe_ 'skip', _chick_, _chili_, _jiddisch_ are always given a phonemic structure

/..ji../ and seem to be completely acceptable to Danes. Thus it can be concluded that homosyllabic /CV/-sequences in Danish do not exhibit any combinatory restrictions.

Let us, finally, turn to the /VC/-sequences, and let us, for the moment, disregard the phoneme sequences which are manifested by genuine (in the sense discussed in section 3 above) phonetic diphthongs (see below).

Since we are concerned with *structural* (as opposed to accidental) occurrence and non-occurrence of combinations, we ought not to use morphemes as our frame of reference. This follows from the fact that we are interested in the restrictions mastered "productively" by the native speaker, together with the hypotheses (if they are correct) that new monomorphemic words can be freely introduced without phonotactic modifications if they conform to the structure valid for polymorphemic native words (cf. Basbøll 1973b) and the more general hypothesis explored by Linell (1974) that *psychologically central invariant structurings* correspond (by and large) to the *maximally distinct word forms*. We take this criterion of maximally distinct word forms to imply that *stylistic shortening* (i.e. the *optional* shortening of long vowels (particularly high vowels and stød-vowels) before the non-consonantal non-syllabic phonemes, i.e. the "glides" [i̯, u̯, ɒ̯, ð, (ɣ)]) should be *disregarded* for the purpose of this investigation. I.e., since this shortening is *not* obligatory, the maximally distinct (with "maximal structuring") word forms will be those with *long* vowels, for the words in question. On the other hand, it is clear that word forms having undergone *morphological shortening*, i.e. the (generally) *obligatory* shortening of underlying long vowels, e.g. in the first part of certain compounds and in stems before certain suffixes, should be included in the material (cf. the fact that the vowel quality in *morphologically* shortened forms most often is identical to that of "genuine" short (as opposed to long) vowels, in contradistinction to the *stylistically* shortened vowels).

It is an empirical question which type of words (and thus which word-definition) we should use here (if we are concerned with the productively mastered phonotactic restrictions). I shall tentatively employ words not containing any # (cf. my paper "Grammatical boundaries in phonology" in this volume), i.e. disregard compounds (and certain productive pre- and suffixes, but this has little impact on phonotactics).

If the vowel is long, there is free combinability with the following consonant, except for the fact that /j/ does not occur after long vowels, and that /œː/ can only be followed by /r/ or /n/ (and by /l/ in the word brøle 'roar', but this only applies to the conservative language, the [œː] in brøle in younger standards having been coalesced with the (original) r-coloured /øː/).

When the vowel is short, the only restriction which might be systematic is the non-occurrence of high front vowels before nasals (short [u] occurs before /n/: hun 'she', hund 'dog', pund 'pound'). As regards (stressed) /i/, the restriction is probably not structural: The name Kim today is often pronounced [kim?], and the foreign word pinje 'stone pine' is usually pronounced [pinjə].[1] As regards /y/, words like kymrisk 'Cymric', hymne 'hymn' [kym?ʁisg/køm?ʁisg, hymnə] suggest the same thing; and in pretonal syllables short [y] freely occurs before homosyllabic nasals (e.g. syntese 'synthesis', gymnastik 'gymnastics' [syntéːsə, gymnasdíg]. (But if the non-occurrence of short (stressed) [y] before nasals should have turned out to be systematic, a rule could be set up to the effect that round front vowels are lowered one degree before nasals (cf. Spang-Hanssen 1949 and Basbøll 1972b), and in that case the phoneme /y/ would in fact occur before nasals.) If short [y] is structurally allowed before homosyllabic nasals, which seems to be the case, the non-occurrence of short [œ] in other positions than before a homosyllabic nasal or after /r/ is probably to be considered systematic. This restriction is best conceived of as concerning

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1) The word trin 'step' is often pronounced [tʁin].

the vowel phoneme /œ/ (cf. the restricted occurrence of long /œ:/ mentioned above) and not the consonants. This restriction must be borne in mind in the following.

It can thus tentatively be concluded that there are no secure structural restrictions, apart from the restricted occurrence of the phoneme /œ/, for the combination /VC/ within the syllable, disregarding the sequences manifested as phonetic diphthongs (this may, in fact, be seen as one of the characteristics of the distinction between the classes of functional vowels and consonants, respectively).

Let us now turn to the /VC/-sequences which are manifested as genuine phonetic diphthongs. As regards the [ɒ̯]-diphthongs, one restriction is generally mentioned in the literature: the non-occurrence of the short mid-close vowels /e, ø, o/ before /r/. However, a few words with /or/ are found (e.g. sort (adj.), hurtig, mor, some of which have alternating pronunciations); also compare the name Per [pe(:)ɒ̯] (cf. section 3.4.2 above). Furthermore, the phonetic diphthongs [eɒ̯, øɒ̯, oɒ̯] are quite common in the first part of compounds and certain derivatives, where they occur by morphological shortening (e.g. lergulv 'earthen floor', mørbanket 'beaten black and blue', stormand 'magnate' [ˈlẽɒ̯gɔ̀l, mø̃ɒ̯bɑ̀ŋʔgð̩, sdõɒ̯mànʔ]). (Finally, [eɒ̯, øɒ̯, oɒ̯] frequently occur as a result of stylistic shortening (e.g. ler 'clay', mør 'tender', stor 'great' [ˈleɒ̯ʔ, møɒ̯ʔ, sdoɒ̯ʔ]), but this can be disregarded at present, cf. above.) Within the present context, the alleged non-occurrence of /e, ø, o/ before /r/ should thus not be considered structural (but see below), and the phonetic [ɒ̯]-diphthongs are not systematically deviant from other /VC/-combinations in this respect.

Concerning the [u̯]-diphthongs, the over-all picture (which will only be sketched here) does not differ much from that of the [ɒ̯]-diphthongs just mentioned. The diphthongs [iu̯, eu̯, ɛu̯, yu̯, øu̯, œu̯, ɒu̯, ɑu̯] (e.g. stivne, levret, levne, syv, løvfald, støvle, bov, hav) all seem to be readily acceptable to Danish speakers, and they are all found in native words, although some of them only occur as a result of morphological shortening or in isolated roots; the [u̯]-diphthongs with open first vowel freely occur in monomorphemic native words (see below). Thus the [u̯]-diphthongs do not exhibit any structural phonotactic restrictions (with the possible exception of [uu̯] and [ɔu̯], but cf. fog), in the sense used at the moment, and they must be considered phonotactically non-deviant /VC/-combinations.

Finally, let us consider the [i̯]-diphthongs. Here the picture is different. The diphthongs [ɑi̯, ʌi̯] are perfectly acceptable, and the diphthong [ui̯] is found in one native stem, viz. huj. The diphthong [ɛi̯] is the most general pronunciation in English loanwords like baby [bɛi̯bi] (where the older generation often has [ɛ:]: [bɛ:bi]). But diphthongs like [ei̯, yi̯, øi̯, œi̯, oi̯] are clearly excluded. (As mentioned above, we disregard the stylistically shortened diphthongs which may occur in words like neg 'sheaf', syg 'ill', besøg 'visit' [nei̯?, syi̯?, besøi̯?] (together with non-shortened forms as well as forms without the glide); note, however, that e.g. [oi̯] never occurs as a result of stylistic shortening (nor as a result of any other phonological process).) Let us, therefore, define a phonological diphthong in Danish in the following way: If there are (heavy) systematic restrictions on the choice of different vowel phonemes that can precede a given consonant phoneme belonging to the same syllable, then the /VC/-combinations in question are phonological diphthongs; or, in other words: phonological diphthongs are homosyllabic /VC/-combinations exhibiting (heavy) systematic phonotactic restrictions of (internal) combinability.

This definition implies, as already mentioned, that the Danish [i̯]-diphthongs can be considered phonological diphthongs (quite independently of their manifestation as phonetic diphthongs), in contradistinction to the [u̯]- and [ɒ̯]-diphthongs. It should be added here that the so-called [ð]-diphthongs (see section 2.3 above), clearly do not satisfy this definition of a phonological diphthong: [ð] is freely combinable with the preceding vowel. This definition recalls earlier phonological definitions suggesting that a phonological diphthong is a phonetically complex vowel behaving like a single phoneme (cf. Pike 1947a, pp. 62 and 149); the two definitions have in common that they emphasize the tight connection (phonologically speaking) between the two parts of the diphthong. The latter definition does not cover any Danish diphthongs, however (whereas it seems more appropriate to languages like English). It may be added that the result of these considerations, viz. that [i̯]-diphthongs can be considered phonological diphthongs in contradistinction to the other phonetic diphthongs in Danish, agrees well with certain aspects of Danish graphemic structure, cf. Spang-Hanssen 1959, p. 191 ff).

If we now restrict the view to phonotactic regularities of underlying morphemes, another picture emerges, viz. that the phonetic diphthongs generally, i.e. also [u̯]- and [ɒ̯]-diphthongs, exhibit a more restricted internal combinability than other /VC/-sequences. It should be emphasized, however, that underlying morphemes are highly abstract entities which seem to be of a dubious psychological relevancy (as opposed to concrete word forms). It may nevertheless be interesting briefly to survey the distributional facts from this point of view, too. When we are so restrictive as to exclude morphologically shortened forms from consideration, we shall also be allowed to exclude a few isolated monomorphemic forms as exceptions, by Spang-Hanssen's criterion of generalizability (op. cit.). We are here, in other words, concerned with the core of non-alternating diphthongs (cf. section 3.4.1 above).

The core of [ɒ̯]-diphthongs are derived from a short high or low vowel phoneme plus /r/, i.e. the combinations /er, ør, or/ do not belong to the core.

The core of [u̯]-diphthongs all have a low vowel as their first component: [ɛu̯, œu̯, ɒu̯, ɑu̯]. Thus these diphthongs, too, are deviant from other /VC/-combinations under the present presuppositions (viz. that we disregard morphologically shortened forms).

The <u>core</u> of the [i̯]-diphthongs consists of only [ʌi̯] and [ɑi̯], as already mentioned.

When we consider the [Vð]-sequences, on the other hand, even the core of these represent the quite ordinary free combinability typical of non-diphthongal /VC/-combinations (e.g. <u>bid</u> 'bite', <u>bed</u> '(flower) bed', <u>med</u> 'with', <u>mad</u> 'food', <u>spyd</u> 'spear', <u>lød</u> 'hue', <u>bud</u> 'messenger', <u>lod</u> 'weight' [bið, beð, mɛð, mað, sbyð, løð, buð, lʌð]; the combination of short /o/ plus <u>ð</u> is missing, but such an isolated gap is not peculiar of the /Vð/-combinations).

We have argued throughout this section that, whereas normal (homosyllabic) /$VC_{f1}C_{f2}$/-sequences had a loose connection (i.e. free combinability) between /V/ and /C_{f1}/, and a tight connection (i.e. restricted combinability) between /C_{f1}/ and /C_{f2}/, 'phonological diphthongs' could be defined by the fact that they had a tight connection between /V/ and /C_{f1}/. It should now be investigated whether the counterpart of the tight connection between /V/ and /C_{f1}/ in a phonological diphthong is a loose connection between the second component of such a 'diphthong' (i.e. /C_{f1}/) and a following consonant (/C_{f2}/), according to the following scheme:[1]

'phonological diphthong':[2]	$V \overbrace{\qquad}^{\text{tight}} C_{f1} \overbrace{\qquad}^{\text{loose}} C_{f2}$
other homosyllabic /VCC/-sequences:	$V \underbrace{\qquad}_{\text{loose}} C_{f1} \underbrace{\qquad}_{\text{tight}} C_{f2}$

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1) I am indebted to Henrik Holmboe and Jørgen Rischel for having called my attention to this question.

2) It follows from the arguments to be given below that the [u̯]- and [ɒ̯]-diphthongs in fact constitute a third category, viz.: $V \underbrace{\qquad}_{\text{loose}} C_{f1} \underbrace{\qquad}_{\text{loose}} C_{f2}$

According to the findings of Basbøll 1973b (p. 127 f), there is, in fact, one respect in which the connection between $/C_{f1}/$ and $/C_{f2}/$ is looser if $/VC_{f1}/$ is manifested by a genuine falling diphthong, i.e. by a [i̯]-, [u̯]- or [ɒ̯]-diphthong, in comparison with the case where $/C_{f1}/$ is manifested by a phonetic consonant. This is the restriction that non-dental consonants do not combine in the final part of the syllable.[1] However, /r/ combines freely with following non-dental consonants (e.g. mørk 'dark', sværm 'swarm' [mŒɒ̯g, svæɒ̯ʔm]), presupposing, of course, that the general order restrictions are not violated. And, although genuine falling [i̯]- and [u̯]-diphthongs generally do not occur before homosyllabic non-dental consonants within the native vocabulary, sequences like [ɑu̯g, ɑi̯f, ɑi̯g] are certainly not (structurally) excluded, compare the names Hauch, Leif [hɑu̯ʔg, lɑi̯ʔf] and imperatives like strejk! 'strike!' [sdʁɑi̯ʔg].

By way of conclusion, we can just say that the [i̯]-diphthongs are phonological diphthongs in the sense that they exhibit heavy internal combinability restrictions, in contradistinction to other /VC/-combinations, including the [ɒ̯]- and [u̯]-diphthongs. And further, that also the [u̯]- and [ɒ̯]-diphthongs can be considered phonological diphthongs in the much weaker sense that the corresponding /VC/-sequences exhibit (heavy) internal combinability restrictions within (the core of) abstract morphemes (i.e. when morphologically shortened forms have been excluded from the material, as well as certain exceptional root morphemes). Also,

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1) This formulation presupposes that the nasal in the homorganic sequences [mf, mb, ŋg] be considered a manifestation of the phoneme /n/. This interpretation agrees well with the facts that a final [n] in the first part of compounds etc. may be assimilated as to place of articulation to a following obstruent (e.g. tandkød 'gingiva' [tánkø̀ð/táŋkø̀ð]), in contradistinction to [m, ŋ] (e.g. tamgæs 'domestic geese', ungdom 'youth', sangbog 'songbook' [tɑ́mgɛ̀s/*tɑ́ŋgɛ̀s, ɔ́ŋdʌ̀mʔ/*ɔ́ndʌ̀mʔ, sɑ́ŋbɔ̀:ʔu/*sɑ́mbɔ̀:ʔu]), and that monomorphemic [md, ŋd] are not assimilated (e.g. amt 'county', punkt 'point' [ɑmʔd/*ɑnʔd/*anʔd, pɔŋʔd/*pɔnʔd]).

the falling [i̯]-, [u̯]- and [ɒ̯]-diphthongs can be considered phonological diphthongs in the sense that they represent a particularly loose connection to a following homosyllabic consonant. Finally, it was noted that Vð-sequences, although they can be considered phonetic diphthongs, are not to be classified as phonological diphthongs in any of the senses discussed above.[1]

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1) Notice that the restrictions between /ð/ and the following consonant phoneme are particularly heavy (cf. Basbøll 1973b) so that Vð cannot, by any means, be considered a phonologically "tight" /VC/-sequence.

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GRAMMATICAL BOUNDARIES IN PHONOLOGY

Hans Basbøll

Abstract: This paper[1] is divided into two main parts: (1) on grammatical boundaries in generative phonology, including an overview of boundaries in the phonology of French, and (2) which concentrates on the evidence for grammatical boundaries, and where both French and Danish examples are discussed. This bipartition is mainly made for expository reasons, and there is a considerable overlapping in the contents of the two sections.

1. Grammatical boundaries in generative phonology

1.1 Boundaries in relation to syntax

Within the transformational-generative paradigm questions like the following are central for the discussion of boundaries: By which convention(s) are boundaries inserted? Are they inserted on the basis of the syntactic surface structure alone (possibly in the readjustment component), or does the insertion of boundaries depend on information which is available only on deeper syntactic levels? If the latter is the case, are the boundaries moved (by movement-transformations) together with the material they delimit, or are they left behind? How are the boundaries affected by the readjustment rules? I shall not try to discuss these and similar questions here (let alone try to answer them), since this approach implies the serious danger

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1) The paper was read at the Second Meeting of Scandinavian Linguists, held at Oslo on April 19-20, 1975, and at a guest lecture at the University of Uppsala on May 22, 1975. I am indebted to Eli Fischer-Jørgensen, Jørgen Rischel, Nina Thorsen and Oluf Thorsen for helpful comments on the manuscript.

of over-axiomatising empirical issues (cf. Derwing 1973, Linell 1974). I.e., so long as the theory of transformational-generative grammar is not more well-established empirically than seems to be the case for the moment, the answers to the questions raised in this paragraph must remain equally uncertain.[1] It seems wiser to me to take an alternative point of departure as mentioned below.

1.2 Boundaries in relation to phonology

1.2.1 Inventory of boundaries

According to the principle of 'Occam's razor', no more structure should be postulated than is necessary to account for the observed data. Concerning boundaries, the 'null-hypothesis' which, accordingly, should be tried before we move to more complex hypotheses, is that no grammatical boundaries are phonologically relevant. Each proposed distinction in boundaries (i.e. each new boundary type introduced) must be separately justified on purely phonological grounds.[2]

1.2.2 Function of boundaries in phonological rules

According to Chomsky/Halle 1968, boundaries are units (in the phonological string) which are cross-classified by distinctive features (viz. the features [word boundary (WB)] and [formative boundary (FB)]). In addition to # ([+WB, -FB]) and + ([-WB, +FB]), they operate with a = ([-WB, -FB]), a boundary

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1) Furthermore, the use of syntactic surface structure (SS) in phonology also implies the danger of circularity, since facts of pronunciation (e.g. intonation and stress) are sometimes used as clues for SS.

2) Thus I do not accept an argument like the following: We can define a large number of different boundary types on grammatical grounds, and each of these boundaries is potentially a phonologically relevant boundary which can be used at will (without any 'cost', i.e. added complexity) by the phonological component, since the input to phonology is the syntactic component (possibly via the readjustment component).

the postulation of which has been (justly) criticized from many sides (apparently Chomsky/Halle do not consider the possibility of a boundary [+WB, +FB]). If a specific boundary is mentioned in the SD of a phonological rule, it only applies to strings containing the mentioned boundary at the indicated place. Apart from that, all occurrences of + in the input string to a rule are irrelevant for the application of the rule, whereas all occurrences of #, on the other hand, block its application (unless, of course, a # is included in the SD at the appropriate place).

McCawley 1968, in contradistinction to Chomsky/Halle 1968, proposes that boundaries be (linearly) ordered in a strength-hierarchy. The main function of boundaries is, according to him, that they serve to define the <u>domain</u> of rules. Thus, each phonological rule has a certain boundary as its "rank", and each occurrence of a boundary of this rank as well as of a stronger one serves to delimit (on one side) the extension of each chunk to be compared with the SD of the phonological rule. This has become known as the <u>ranking</u> function of boundaries. I think it is more or less agreed today that McCawley's hierarchical model of boundaries is superior to the <u>SPE</u>-model.

Stanley 1973 distinguishes between three functions of boundaries with respect to phonological rules: (1) rules ranked by a certain boundary (or stronger ones), i.e. the function proposed by McCawley; (2) rules delineated by a certain boundary (or stronger ones), e.g. the rule which devoices final obstruents in German; and (3) rules requiring a specific boundary in their SD. Stanley furthermore argues that if rules are formulated by means of variables, e.g. the mentioned final devoicing rule <u>not as</u>: $[-\text{son}] \longrightarrow [-\text{voi}]\ /\ \_\_\_\ \#$

<u>but instead as</u>: $X\ \begin{array}{c}[-\text{son}]\\ \downarrow \\ [-\text{voi}]\end{array}$ <u>RANK</u>: #

(where X indicates that segments may occur at the left-hand side of the environment and, consequently, the lack of a variable to the right of [-son] indicates that the obstruent must be final in the relevant chain # ___ #), then (1) and (2) above reduce to one type. (According to the conventions of Chomsky/Halle, on the other hand, rules of type (2) reduce to type (3), since stronger boundaries than # are symbolized by a sequence of #'s; the SD [-son]# is thus also satisfied by [-son]## etc.)

The examples adduced as support for Stanley's type (3), i.e. rules requiring a specific boundary in their SD, seem dubious to me: they are mostly taken from the analysis of English stress and vowel shift by Chomsky/Halle, and their account of these phenomena seems dubious by any standard. Thus, it may be concluded that the only well-established function (or at least the central function) of boundaries is ranking, presupposing, as already mentioned, that variables are used in the notation of phonological rules, in the way suggested by Stanley.

1.3 An example: boundaries in French phonology

1.3.1 Inter-word boundaries

The 'null-hypothesis' concerning inter-word boundaries, i.e. that no inter-word boundaries are phonologically relevant, has never, to my knowledge, been seriously proposed. Nor have other very simple hypotheses, e.g. that all inter-word boundaries have the same phonological effect.

Selkirk (1972) found a distinction between two types of inter-word boundaries which she (following Chomsky/Halle 1968) formulated as # (separating words in a 'liaison-context'; they may be called 'weak word-boundaries') and ## (separating words in a 'non-liaison context'; they may be called 'strong word-boundaries'). She found that the notion 'liaison-context' was relevant for the application of several phonological rules. (I shall not discuss her evidence here.)

Selkirk viewed her results as a striking support of the basic claims by Chomsky/Halle concerning boundaries, in the following two respects: (1) There is (in French) only a distinction between # and # #, which follows from Chomsky/Halle's principles of # -<u>insertion</u> (where # is inserted on both sides of a major lexical category, i.e. N, V and A, and on both sides of categories dominating a major lexical category), together with their principles of <u>reduction of sequences of # 's longer than two</u>. (2) She found, in agreement with the principles of Chomsky/Halle, that there was never more than one # between a non-major lexical category and an adjacent major lexical category belonging to the same phrase, e.g. between a preposition and a following noun in a prepositional phrase, or between an article and a following noun in an NP. In order to account for the liaison-phenomena which are highly dependent on style level (briefly: the higher the style, the more instances of liaison), she had to introduce a number of rules with the effect of reducing # # to # in a given style, under certain <u>grammatical</u> conditions. E.g. the sentence <u>le petit homme prend un instrument affreux</u> is in labelled bracketing notation:

$$[_S\,[_{NP}\,\text{le}\,[_A\,\text{petit}\,]_A\,[_N\,\text{homme}\,]_N\,]_{NP}\,[_{VP}\,[_V\,\text{prend}\,]_V\,[_{NP}\,\text{un}\,[_N\,\text{instrument}\,]_N\,[_A\,\text{affreux}\,]_A\,]_{NP}\,]_{VP}\,]_S$$

It receives the following boundary structure (in two tempi) according to the Chomsky/Halle principles (taken over by Selkirk):

$$\#\#\,\text{le}\,\#\,\text{petit}\,\#\#\,\text{homme}\underbrace{\#\#\;\;\#\#}_{\#\#}\text{prend}\,\#\#\,\text{un}\,\#\,\text{instrument}\,\#\#\,\text{affreux}\underbrace{\#\#\#\#}_{\#\#}$$

In casual style, a rule reduces # # to # between an A and a following N in an NP (i.e. petit # # homme ⟶ petit # homme);

in higher styles, ## is reduced to # also between V and NP in a VP (i.e. prend##un ⟶ prend # un); only in a very high style, however, is ## reduced to # also between an N and a following A in an NP (i.e. instrument##affreux ⟶ instrument # affreux) (these facts of pronunciation can be found in most traditional textbooks, by Grammont and others).

I have three observations to make on this issue: (1) Selkirk's evidence, of course, does not at all concern the specific two-step derivation of boundaries by Chomsky/Halle (cf. Wurzel's (1970) alternative one-step derivation, containing features taken over from Bierwisch 1966). It only concerns the general claim that not more than two different types of sentence-internal inter-word boundaries may occur. (2) According to Chomsky/Halle/Selkirk it should be completely excluded, in any level of style, that ## could occur between an adverb in their theory belonging to a non-major lexical category, and the adjective (or participle) it modifies. This is true of très (très aimable has obligatory liaison, cf. the old spelling convention très-aimable), but in casual spoken French there need not always be liaison after bien (bien évident), and after beaucoup liaison is quite often not made (beaucoup aimé). (3) According to several investigations of "word-reduction"-phenomena (e.g. by Wolfgang Dressler and Håkon Eriksson, cf. Linell 1974, p. 67 ff (with references)), it appears generally to be the case that the more casual or "reduced" the style level becomes, the more grammatical boundaries lose their effect. But in Selkirk's framework, exactly the opposite is the case: the higher and more distinct the level of style becomes, the more instances of ## are reduced to # . This problem will be taken up in section 2.5 below.

The sentence boundary can be phonologically relevant also in French, as discussed by Dell (1973). I propose the notation ### for a sentence boundary, in agreement with the notations ## and # for strong and weak sentence-internal inter-word boundaries, respectively. This notation directly shows the rank of the sentence boundary (cf. section 1.2 above); and according to the Chomsky/Halle conventions it codifies the hypothesis that a process taking place before a word-boundary also applies if the word is sentence-final, whereas a process taking place only sentence-finally does not apply word-finally if the word occurs in the middle of the sentence.

1.3.2 Intra-word boundaries

The 'null-hypothesis' can be easily dismissed. Dell 1973 uses the plus sign (+, i.e. 'morpheme boundary') for all word-internal boundaries, and no others. If this use of + is considered to be an automatic consequence of the *definition* of +, it is of course empirically vacuous and hence infalsifiable. But if, on the other hand, it is considered to be a testable *hypothesis*, it can be rephrased like this: "all word-internal boundaries have the same phonological effect, and this differs from the effect of all inter-word boundaries". This interesting hypothesis cannot stand up to the testing (see below).

Lisa Selkirk (1972) operates with a word-internal boundary =, in addition to +. = is supposed to occur between prefixes like *in-*, *con-* and learned stems, thus accounting for the dropping, she suggests, of the prefix-final nasal before stems beginning with a sonorant consonant, e.g. *illégal*, *commémoratif*. I find this use of = no better motivated than the similar use of = in English by Chomsky/Halle, since these learned formations are predictable, by the very fact that the stem is [+savant], a categorization which is needed anyhow to account for a lot of learned morphology in French (and to introduce the boundary =!), cf. native words like *immangeable* [ɛ̃mɑ̃ʒabl].

In a forthcoming paper, I have discussed word-internal grammatical boundaries in French extensively. In the present paper, I shall therefore limit myself to a brief summary, and refer the reader to Basbøll forthcoming for further discussion and documentation.

I propose a distinction between two types of word-internal grammatical boundaries in French, which can be symbolized by + and #, respectively. + is considered irrelevant for the application of phonological rules proper (as a consequence, no phonological rule contains a + in its SD). + may be relevant only for principles of structuring the phonological chain, i.e. for morpheme structure conditions and for principles of phonological syllabification. #, on the other hand, can block certain phonological rules (see below), and, as the notation implies, the word-internal occurrences of # have the same phonological effects as the # occurring between words in a 'liaison-context', as will be further clarified below.

The principles predicting the occurrence of # vs. + are: # occurs after prefixes and before the (obstruent) endings /z/ and /t/. (/t/ is the 3^{d} ps. ending, and /z/ the non-third (i.e. 1st and 2^{d}) ps. ending, as well as the plural ending in nouns, adjectives etc.; these endings can thus be defined *grammatically*, and the phonological characterization is probably only to be considered a short-hand device, cf. Basbøll forthcoming. It should not be excluded *a priori*, however, that an obstruent can more easily be separated phonologically from the rest of the word.) + occurs before (other) suffixes. # occurs after proclitics and before enclitics, except that there is only a + before an enclitic subject pronoun. This can be (informally) abbreviated in the following formula for a 'major phonological word' in French (see below) - the notation presupposes that none of the #-reduction rules ($\#\#\longrightarrow\#$ in a given style under certain grammatical conditions) proposed by Selkirk (see section 1.3.1 above) have been applied:

$$\#\#(\text{proclitic}\#)_0\ (\text{prefix}\#)_0\ \text{stem}\ (+\text{suffix})_0(\#\begin{Bmatrix} z \\ t \end{Bmatrix})\ \left\{\begin{matrix} (+\text{enclitic subject}) \\ (\#\text{enclitic non-subj.})_0 \end{matrix}\right\}\#\#$$

(o means that the content of ( ) is present zero, one or more times.) - The formula is slightly inaccurate in one respect: a form like parlé-je, which is ##parl+ə # z # ʒə ## (I argue in Basbøll forthcoming that the personal ending /z/ should be present in the underlying form (and later be deleted by the truncation rule), but whether this claim is true or not, is completely irrelevant in the present context) immediately after the application of subject-clitic-inversion (which is, according to Kayne, a syntactic transformation distinct from the other clitic movement transformations), is converted into ## parl+ə+z+ʒə ##, i.e. all internal #'s are reduced to + in such forms, cf. Basbøll forthcoming.

This model should be interpreted in relative (as opposed to absolute) terms: it predicts e.g. that there is a stronger boundary between prefix and stem than between stem and suffix, and, in parallel fashion, that there is a stronger boundary between a verb and an encliticized object pronoun, compared to an encliticized subject pronoun. E.g. in most styles a stem-final high vowel is desyllabified before a suffix beginning with a vowel (e.g. niant, maniaque [njã, manjak]), but not a prefix-final high vowel before a stem beginning with a vowel (e.g. antiatomique, biannuel [ãtiatɔmik, bianɥɛl], not *[ãtjatɔmik, bjanɥɛl]); and there are no styles which permit glide formation in the latter but not in the former case. Similarly, in many styles there is vowel harmony between a stem and a suffix (under certain phonological conditions), e.g. cédant [sɛdã, sedã], but not between a prefix and a stem (under identical phonological conditions), e.g. prétend [pʁetã], not *[pʁɛtã]; and there are no styles which permit vowel harmony in the latter but not in the former case. This offers evidence for the stronger boundary between prefix and stem compared to stem and suffix. But it does not, of course, exclude that in much more reduced styles there can be glide formation and vowel harmony in all the situations mentioned.

Our parallel treatment of prefixes and proclitic "words" is supported e.g. by the identical treatment of en in both functions, compare enivrer, en avril [ãnivʁe, ãnavʁil], emmener, en Mauritanie [ãmne, ãmoʁitani].

The independent status of the endings /z/ and /t/ is shown by the fact that the part of the word before these endings is in all respects treated as if it occurred independently, e.g. with respect to schwa-treatment and stress. One may also refer to the pronunciation [zami] (in non-standard French) for amis! which suggests that /z/ is reanalysed as a plural-prefix. Finally, a great simplification of French verb morphology is obtained by the proposed analysis.

The particularly tight connexion between a verb and an encliticized subject pronoun is indicated by the following facts: (1) /ə/ is regularly deleted in -je, -ce, etc. (suis-je, est-ce [sɥi:ʒ, ɛs], etc.), whereas it bears the word-stress and is never deleted in e.g. prends-le, sur ce, parce que! and others. (2) Vowel harmony may occur, even in relatively high styles (acceptable to Grammont!) in est-il, es-tu [etil, ety], but only if the enclitic is subject. (3) The distinction between /e, ɛ, ə/ is always neutralized in favour of ɛ in phonologically closed syllables (a notion which is defined in Basbøll forthcoming). If the vowel is immediately followed by #, the syllable is never (phonologically) closed. Thus there is neutralization in favour of ɛ in parlé-je (prés.), parlai-je (ps. simple), parlais-je (impft.), all pronounced [paʁlɛ:ʒ] (with vowel length conditioned by the following homosyllabic ʒ, which agrees well with the hypothesis that je is treated as a suffix); on the other hand, /ə/ is kept as /ə/ in parles, parlent, /parl+ə # z, parl+ə # t/.

1.3.3 Ranking of some French phonological rules

The boundaries discussed here, i.e. the sentence boundary # # #, the strong word boundary # #, the weak word boundary (identical to the strong word-internal boundary) #, and the morpheme boundary (i.e. the weak (or irrelevant) word-internal boundary) +, define four possible ranks of phonological rules (principles of structuring, in the case of +) in French.

A fifth boundary, of a different type, is the syllable boundary $ (cf. Basbøll 1974). Thus we have established five possible ranks, each defining the extension of a phonological chain which can serve as the domain for phonological processes. Below I shall enumerate these five phonological chains and in each case mention one or more processes which can apply to the chains in question. As mentioned in section 1.3.2 above, increasing "word-reduction" implies that more and more processes apply to longer and longer chains (corresponding to a decreasing effect of the boundaries in question). This phenomenon is disregarded in the following, where we only consider a rather distinct level of style (with a high degree of segmentalization, cf. Linell 1974, p. 66 ff).

(1) '<u>Phonological sentence</u>'. Rules of rank # # # : phenomena in the beginning and end of (phonological) sentences, concerning schwa-dropping (cf. Dell 1973); in lower levels of style, certain "word-reductions" (such as assimilations) apply with the phonological sentence as their domain.

(2) '<u>Major phonological word</u>'. Rules of rank # #: liaison and stress ('accent du syntagme'); the 'major phonological word' includes pro- and enclitics.

(3) '<u>Minor phonological word</u>'. Rules of rank # : word stress, vowel harmony and glide formation. 'Minor phonological words' are the parts of the 'major phonological words', e.g. 'bound pronouns' (except encliticized subjects) and particles,

but also, according to the present definition, prefixes and the endings /z/ and /t/ (and the rest when all these morphemes are subtracted from the 'major phonological word', viz. a stem or a stem plus suffix(es)).

(4) The morpheme (or formative). There are no phonological rules proper of the rank +, but morpheme structure conditions (MSC) have + as their rank. It should be emphasized, however, that MSC are "abstract rules" and thus of dubious (psychological) relevance. (The principles of phonological syllabification (as proposed in Basbøll forthcoming) have # as their rank, but under very restricted conditions they pay attention to a + in their structural description.)

(5) The syllable. Rule of rank \$: "closed syllable adjustment", i.e. the neutralization of /e, ɛ, ə/ in phonologically closed syllables in favour of ɛ. On more concrete levels, the syllable seems to play an even more important role (cf., e.g., Schane 1973, p. 52 ff). It may be added that phonetic syllables represent a structuring of the linguistic expression (Hjelmslev's term) so that it becomes easier to en- and decode (whereas grammatical boundaries merely represent a projection of higher level information onto the sound chain).

These ranks seem to occur frequently in other languages, and it might be possible to identify them on a cross-linguistic basis, including their function as domain for rules. E.g. the 'phonological sentence' may be defined as the maximal domain for rules, and the 'minor phonological word' as the minimal domain of phonological rules proper, disregarding the syllable which can be defined on independent grounds. The 'major phonological word' can then be characterized by means of its relative position in between the 'phonological sentence' and the 'minor phonological word'. The morpheme (or formative), just like the syllable, can be defined independently of its function as a rule domain. Let me finally mention that the notions 'pro- and enclisis' seem to be relevant in many languages, and they follow in a natural way from the use of ranks discussed here.

Note that the rules mentioned under (1), (2) and (3) above represent productive processes, not abstract morphemic relationships.

2. Evidence for grammatical boundaries in phonology

2.1 Descriptive convenience

If the postulation of a given grammatical boundary only serves to define the domain of one rule it is, of course, circular. But if several rules require the same boundary structure, which furthermore does not complicate the description of any other rules, then a simplification of description can be obtained by using boundaries (as in the French example). Notice that this "simplicity" argument makes no claims as to psychological reality of the boundaries in question.

Within the generative paradigm, it would be considered very important whether the boundaries postulated are part of a universally proposed inventory, and, more generally, whether the principles of boundary structure follow (at least in part) from 'linguistic theory'. Thus it would not be considered circular, within this paradigm, to operate with a grammatical boundary which only had an effect on one phonological rule, if the occurrence (and location) of this boundary could be predicted from the theory (boundaries should not be postulated on the basis of phonological criteria alone, i.e. in the absence of any syntactic-semantic evidence for some sign boundary at the given location).

2.2 Independent definability of the boundaries

In the case of French, the boundaries can be defined independently of their phonological impact (which motivated the phonological use of the boundaries in the first place); this definition, furthermore, does not presuppose knowledge of individual lexical items: it only refers to notions like 'prefix, suffix, subject (and possibly obstruent)'. These notions are probably learnable (cf. Derwing).

2.3 Speculations on linguistic evidence of a non-phonological kind

In French, prefixes seem to be phonologically more independent of the stem than suffixes. This may be related to the following observations: (1) prefixes (in French) often appear to have more content than suffixes, (2) suffixes typically change the word-class of the stem (while not affecting the meaning of the stem), in contradistinction to prefixes, (3) prefixes are often lexically identical to separate words (e.g. par, pour, de, à), in contradistinction to suffixes.

There is a distinction between il y a meaning 'he (etc.) has there' and 'there is', respectively: [il i a] (son argent, à la banque) vs. [il j a] (du monde ici). This difference in pronunciation agrees with an analysis of the former case as (il #) y # a, where y is an independent word, meaning 'there' (standing for "à+PRO" under certain conditions), and where any other combination of subject-verb might have occurred instead. In the second case I suggest an analysis (il+)y+a, in agreement with the completely frozen behaviour syntactically and semantically, cf. that il y a is often referred to as a 'particle' (in agreement with its lack of declinability in number and person).

2.4 Manifestation of boundaries

Another point is that # # and # # # are probably potential pauses. This raises the further question whether all boundaries can be manifested (in a more direct way than by their impact on phonological rules like those mentioned above). If certain quantity- (and other, e.g. F_o or intensity) relations obtain in respect to boundaries, this may 'count' (for the language user) as 'manifestation (of the boundary)'. This important issue is very much open. I thus do not agree with the (somewhat unclear) claim of Chomsky/Halle and others that all grammatical boundaries must be erased at the end of the phonological component: If the phonological component (in this context) is meant to exclude 'phonetic detail-rules', then all boundaries cannot be erased at the end of the phonological component since the phonetic detail rules undoubtedly presuppose the boundaries for their correct specification of the phonetic output (e.g. as to the quantity of initial vs. final allophones). If phonetic detail rules are included in the phonological component, on the other hand, it is hard to see that the output of this component could be the mentally relevant phonetic structure, since we do not generally perceive the mentioned quantity relations as such, but instead use this information to structure the sound chain. (A quite different problem here is the distinction between languages like French and German, where phonetic syllabification is highly dependent on word boundaries in German but not in French. This distinction might be easier accounted for if word boundaries are erased at different levels in French and German, but this is, of course, highly speculative.)

2.5 Psychological reality of boundaries

Psychological reality of phonological constructs is no well-defined property: it has several 'layers', and the question can be approached by different means which need not give uniform results (cf. Linell 1974 with references). The general problem cannot be dealt with here. Concerning boundaries, one aspect of the question is the analyzability of complex forms which might be revealed by means of psychological tests.

As already mentioned, there is a formal distinction between the function of boundaries with respect to level of style pointed out in section 1.3.1 above, viz. that # # are reduced to # in higher styles according to Selkirk's description of liaison, whereas word reductions (belonging to lower style levels) normally become more and more radical when boundaries are weakened (or erased). It is common for liaison and word reduction that <u>absence of segments</u> belongs to lower (as opposed to higher) styles. It is also common for liaison and word reduction that <u>application of the rule</u> belongs to lower (as opposed to higher) styles, which seems to be the normal case for optional rules (in agreement with the <u>diachronic</u> fact that people who do not have a "new" pronunciation generally find it "vulgar"). Thus, what is common to the two cases has to do with the <u>process</u> of "reduction", not with the environment in which it occurs. The formal distinction can be reduced to the fact that the # -reduction rule in a case like $C\#\#V \longrightarrow C\#V$ <u>bleeds</u> the truncation rule which applies to $C\#\#$ (and to $C\#C$), but not to $C\#V$ (whereas a boundary deletion will normally <u>feed</u> other rules). The psychological relevancy of this observation is not clear, but the possibility should be examined that the optional <u>phonological rules</u> (in casu: truncation (i.e. non-liaison) as well as word reduction processes) are more relevant psychologically than # -reduction rules of the type proposed by Selkirk. This seems rather plausible to me.

Below, I shall briefly discuss some Danish examples from the standpoint of <u>productivity</u>, and furthermore mention data from <u>sound change</u> and <u>optional rules</u> which appear to suggest the reality of <u>some</u> but <u>not</u> <u>all</u> intra-word grammatical boundaries.

<u>2.6 An example: some suggested evidence for some grammatical boundaries in Danish phonology</u>

<u>2.6.1 The distinction between # and ##</u>

In Danish (like in French) there seems to be a distinction between "strong" and "weak" word boundaries (which can be symbolized by ## and #, respectively). 'Minor phonological words' are pro- and encliticized, i.e. become members of a 'major phonological word', e.g. <u>på # gåden</u>, <u>gør # det</u> (there even exists a particular encliticized form of <u>det</u>, viz. [əð] (together with [də]) with special stødconditions, cf. <u>gør det</u> [gœɐ̯de, gœɐ̯də, gœɐ̯ʔəð]). That enclitics behave like parts of the major phonological word, not only with respect to stress, is shown by the optional rule (in conservative Danish) gd → xd: <u>fægt</u>, <u>kog+t</u>, <u>skæg # t</u>, <u>fik # det</u> [fɛg/xd, kʌg/xt, sgɛ:ʔg/xd, fẽg/xdə], which never applies across ##; i.e., the only inter-word boundaries which allow the rule to apply before them, are the boundaries before enclitics. The distinction between ## and # will not be considered any further here (notice that it is difficult to use intonation and stress as direct evidence for this distinction, since these suprasegmental phenomena may be <u>directly</u> dependent upon the syntactic structure, without the use of grammatical boundaries; cf. Rischel's demonstration (1972) that compound stress can be deduced from the syntactic surface structure without any "cycle").

2.6.2 The distinction between + and

(i) Preliminaries

With respect to stress, there is a distinction between compound stress (i.e. the normal stress pattern of compounds and of derived words with a heavy native suffix like -hed, -dom, -skab) and non-compound stress (the elsewhere case). If compound stress must be assigned in terms of boundaries, an additional boundary (which does not, of course, explain anything) should be set up for this purpose. I leave this issue open here.

Throughout this discussion, we have presupposed the location of all sign boundaries known, and this is, of course, an oversimplification. Within the present framework where the distinction between + and # is supposed to represent the distinction between a phonologically irrelevant and relevant boundary, respectively, this problem is not too serious, since the dubious sign boundaries (if they are recognized at all) will generally be instances of + (i.e. phonologically irrelevant).

(ii) Examples of the proposed boundary structure

I suggest that the boundary # occurs e.g.: (1) before stems (i.e. between the parts of a compound, and between a prefix and the stem, e.g. sól # skìn, úd # gå̀, be # víse); (2) before (primary or secondary) stressed native suffixes, e.g. ven # índe, dúm # hèd (before the primary-stressed suffix inde, certain conservative varieties of Danish only seem to have + , cf. lærerinde [lɛ(:)ʌénə, lɛ(:)ʌʁénə] ; before secondary-stressed suffixes, which are always native, # appears to be obligatory) ; (3) before certain obstruent endings, like /t/ (neuter) and /s/ (genitive).

On the other hand, the boundary + occurs e.g.:
(1) before foreign stressed suffixes like át, í, íst, ísse (e.g. lektorat, perfidi, kontorist, abbedisse);
(2) before unstressed native suffixes like sel, ne (inchoative), me, re (iterative) (e.g. fødsel, gulne, fedme, bladre);
(3) before certain obstruent endings like /t/ (substantivizing).

(iii) Some descriptive evidence

The syllable boundary between two vowels (with intermediate consonants) belonging to different morphemes always occurs at the morpheme boundary if it is #, but not (necessarily) if it is + (in that case the location of $ depends on the sequence of segments). All rules having the syllable as their domain (cf. Basbøll 1974) thus support the different "phonological strength" of the proposed boundaries.

The case of long vowels occurring before a hetero-morphemic cluster in conservative standard Danish are highly restricted (cf. Brink/Lund forthcoming). Our proposed boundary structure restricts this occurrence to $\bar{V}C \# C$-sequences (furthermore there are a handful of isolated roots with $\bar{V}CC$, but there are heavy restrictions on the clusters allowed).

According to Rischel 1970, forms with the ending /t/ either undergo both vowel shortening and consonant gradation (e.g. jagt, stift; cf. jage, stiv), or none of them (e.g. vagt, adj., lavt; cf. vag, lav, adj.). He proposes that the mentioned processes constitute "one complex rule" (although its two "parts" have no intrinsic connection). Within the present framework vagt, adj.: jagt, sb. are vag#t, jag+t, and both rules (i.e. vowel shortening and consonant gradation) are of the rank #. vag#t [væ:ʔɣd] is treated as vag [væ:ʔɣ], and jag+t [jɑgd] as a monomorphemic word like tragt [tʁɑgd].

(iv) Productivity

The natural psychological interpretation of the proposed distinction jag+t : vag#t (adj.) is that the latter is formed productively from vag plus t, whereas the former is stored as a unit (this does not exclude that the language user may be able to perceive the morphological relationship between jage and jagt, but it suggests that the relation is an abstract one). Notice that the neuter /t/ is a productive ending in the linguistic sense, i.e. it can be added to recent loanwords (and to constructed nonsense-words). The substantivizing ending /t/, on the other hand, is unproductive, and the relation between the morphological pairs in question is often not transparent, or at least not unambiguous (both semantically and phonologically), e.g. grave 'dig' : grøft 'ditch', skrive 'write' : skrift 'writing' (although a certain relatedness of sense may be felt in such cases, the nouns in question must generally be considered lexicalized on purely semantic grounds, cf. below).

Productivity is thus a complex phenomenon, and the term 'productive' has been used in different senses. In the following I try to illustrate some different aspects of 'productivity', but I do not know to which degree they ought to be split up or coalesced, i.e., I do not claim that the different aspects below suggest a natural logical system.

When we consider the nature of the linguistic process, e.g. in a psycho-linguistic test situation, we may ask: Is the free form XY (where X and Y are morphemes belonging to the same word) formed productively by the speaker in the given situation, e.g. is the form XY in a concrete test situation formed productively or taken directly from the 'lexicon'? There is hardly any doubt that this question can be investigated empirically, e.g. if the ending Y can be adjoined to constructed nonsense-words, then it is productive, in this sense, at least in the test situation.

If the ending Y can be adjoined to constructed nonsense-words (i.e., if it is productive, in the present sense), we might try to investigate whether the free form XY is constructed, in the speech situation, by rule or by analogy. E.g., if a reference paradigm presented in connection with the test significantly influences the results, this may be taken as indicative of the importance of analogy, at least under such test situations. (Pilot tests of this type have been made by John Ohala.) And although there are undoubtedly enormous problems in undertaking tests which are representative of the normal speech situation, I think, nevertheless, that the question whether rule or analogy is used at a given occasion is a genuine empirical problem.

If a given linguistic device is not used productively in the above sense, I think it is quite misconceived (i.e. bad research strategy, in the present state of our knowledge) to investigate further into the "psychological reality" of the device in question and to make hasty conclusions on the speakers' awareness or non-awareness of this linguistic device.

The term 'productive' is very often used about a linguistic 'device' (e.g. an ending) in the sense 'which can be added to new words which enter the language'. This is what I call 'the linguistic sense (of 'productivity')'. It is an open question whether this phenomenon is identical to one or both aspect(s) of productivity mentioned above. The very fact that rule-productivity and analogy-productivity might, in principle, be distinguished in the test situation leaves room for doubt (and investigation!) concerning the precise nature of 'productivity in the linguistic sense'. To find out whether a given linguistic device is productive or not in this sense, we need not make psycho-linguistic tests, but we should investigate the lexicon of the language during a certain span of time (it is clear that the situation can be found that certain meanings of an ending which is completely productive with regard to its phonological shape and morphology, are unproductive).

Finally, the words 'productive' and 'predictable' sometimes appear to have been used interchangeably, but this seems to me an unhappy choice of terminology since, in principle, these concepts are distinct: an ending like -ning (in Danish) is productive (cf. kodning 'coding', (ned)frysning 'freezing (back)'), but its meaning is not (completely) predictable (cf. skabning 'creature', vejning 'weighing', holdning 'attitude'), and it seems unrevealing to speak of homonymy in the case of the (deverbal substantivizing) suffix -ning as -ning$_1$, -ning$_2$, etc.[a] These forms are better accounted for by assuming that skabning, holdning, etc. are lexicalized, i.e., the meaning of these specific forms must be available in the lexicon (although they are completely regular as to pronunciation).[1]

This is not the place for a general discussion of the linguistic uses (and misuses) of the term 'lexicalization'. I should only like to point to a completely different way of using this term, in addition to the use made above which was, roughly, that a linguistic 'entity' is lexicalized if it contains unpredictable features (one may thus speak of lexicalization for phonological, morphological, syntactic and/or semantic reasons, or, more briefly: an entity may be phonologically, semantically etc. lexicalized, in the present sense).[2]

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1) Similarly, the lexicon must contain information as to the preterite form mødte 'met', with an (optional) short vowel as opposed to fødte 'bore', since the former word is phonologically unpredictable although it is semantically predictable. In a sense, the form mødte might thus be termed 'lexicalized (phonologically)'.

2) This very general use of the term 'lexicalization' may, of course, be partitioned into a number of special types of lexicalization, e.g. the case (which is particularly interesting from the phonological point of view of the present paper) that a grammatical boundary is (exceptionally) ignored for phonological purposes, as we saw in words like jagt discussed above (cf. compounds like ståltråd 'wire' [sdʌ́ltʁɔ̃:ʔð̆]).

a) Also in cases where several of the meanings of an ending are productive (e.g. the nominalizing suffix -er), this ending is, of course, semantically unpredictable (even when only the productive meanings are taken into consideration).

The quite different use of 'lexicalization' alluded to above occurs when one claims that a certain meaning can (or cannot) be lexicalized, in the sense 'qualify as a lexical entry' (e.g., with an example discussed by Richard Carter, the meaning 'be in a certain bodily position' can be lexicalized in English (*stand*, *sit*, etc.), but not in French (*être debout*, *être assis*, etc.), cf. also the universal constraints on 'possible lexical items' discussed by James McCawley in connection with *kill* = *cause*-*become*-*not*-*alive*). It should be noticed that this sense of 'lexicalization' might also cover phonological and morphological structure (since the notion 'possible lexical entry' includes phonological etc. aspects), although the term has most often been used covering semantic constraints only.

Finally, one word of caution concerning the psychological reality of boundaries. *Even if* a form like *færdes* 'move' [fæɒ̯dəs] is analyzable to the native speaker into /fɛrd/+/ə/+/s/ (cf. the preterite form *færdedes* [fæɒ̯dəðəs]), it evidently does not follow that *færdes* is formed productively from /fɛrd/ plus /ə/ plus /s/, and even less that the stem /fɛrd/ is psychologically related to certain other forms, like *færd* 'travel' [fɛ:?ɒ̯]. It can only plausibly be said, I think, that the (psychological) analyzability of a complex form is a *necessary* condition for it to be formed productively by rule.

(v) *Sound change*

Sometimes the term "analogy" is used in a wide sense referring to all cases where a sound change is not purely phonetically conditioned, if the "identity of morphemes" can account for the apparent exceptions, also when *the crucial sounds belong to different words* in the chain (e.g. Brink/Lund forthcoming). Within the present framework this is not to be considered analogy, but is a regular consequence of the fact that sound change generally does *not* affect *sentences* but *smaller* (probably separately stored) units. Given the proposed sound change XA ⟶ XB, where X, A and B are sounds (or classes of sounds), we can investigate which sequences of X-boundary-A are turned into X-boundary-B, and which are not. From this investigation a certain domain of the sound change can be established, and this may shed light on the (psychological) reality of grammatical boundaries in phonology. Most often, recent sound changes in Danish seem to be blocked by the occurrence of # (within the present framework), i.e. they do not apply across the boundaries between the parts of a compound, etc. For example (cf. Brink/Lund forthcoming), the (diachronic and synchronic) rule ɑ ⟶ [-grave] unless before [+grave] (i.e., roughly, ɑ becomes a except before velars and labials, /r/-contexts excepted) accounts for the distinction tand 'tooth' [tan?] : tam 'tame' [tɑm?], etc.; but ɑ does become a before a velar or a labial which is separated from ɑ by a # according to the present framework, e.g. sofapude 'sofa cushion' [sṍ:fapṹ:ðə]. And the (diachronic and synchronic) rule ə ⟶ ʌ/___r applies in fiskeri 'fishing', malerisk 'picturesque' [fesgʌʁí:?, mǽ:lʌʁisg] (although pronunciations with [ə] can be heard); but in compounds like helleristning 'rock engraving', taskerem 'bag strap' [hɛ́ləʁɛ̀sdneŋ, tásgəʁæ̀m?], pronunciations with [ʌ] instead of [ə] are excluded.

When we find isolated examples of apparent compounds or phrases which do nonetheless undergo the change in question, this may be due to the fact that this compound or phrase has been lexicalized, and this can often be confirmed on semantic grounds. I shall only mention two particular (and probably uncontroversial) examples. One is the phrase hvabehar meaning '(beg your) pardon'. Although it is etymologically identical to hvad behager 'what pleases (you)' [va(ð)behǽ:?ɣʌ], it is pronounced [vɑbəhɑ́:?]. The reduction æ:(?)ɣʌ ⟶ ɑ:? has a number of parallels (old doublet forms) which will not be discussed here. But the pronunciation [vɑbə-] instead of [vabe-] indicates that there should be no # between /a/ and /b/ within our framework. This agrees well with the fact that the phrase is completely frozen semantically and syntactically. - The other example is frokost 'lunch' which is normally pronounced [fʁɔgʌsd] (or possibly [fʁɔkʌsd]) although it is (etymologically) compounded from fro [fʁo:ʔ] 'early' and kost [kʌsd] 'food' (via MLG). According to the normal principles for the pronunciation of compounds, it should be pronounced [fʁókʌ̀sd]. Instead, it is treated as a simplex word where /o/ accordingly is lowered to [ɔ]; the weakening of /k/ to [g] may be due to the reduction (from secondary stress to weak stress) of the second syllable, cf. the possible analysis of unstressed [ʌsd] as a manifestation of /ərsd/ (and cf. chokolade [ʃokolæ:ðə, ʃogo-, ʃogə-] etc.). The phonological treatment of the word agrees well with its semantic unpredictability ('lunch' is not semantically equivalent to 'early food'), and with the fact that the word fro is decidedly archaic.

3. Concluding Remarks

The topic of grammatical boundaries in phonology is a crucial one today when a dominating linguistic paradigm, that of generative grammar, has come under severe (and, in my view, justified) attack for empirical vacuity and unsupported and implausible psychological speculations (cf. Derwing, Linell). (Although it can still be defended as a (in some senses elegant) descriptive system.)

If the formations which generativists claim are created by rule (and thus not stored as separate items) are not analyzable (segmentable) for the native speaker, i.e., if the grammatical boundaries postulated have no psychological reality, then the generativist claims seem very weak. But if there are psychologically real (word-internal) grammatical boundaries, on the other hand, we can start investigating whether the morphemes are abstract or concrete, etc. This investigation should, of course, employ scientifically sound methods.

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DANISH R AND ADJACENT SHORT STRESSED VOWELS[1]

Steffen Heger

Abstract: This is a presentation of the main features of the distributional pattern of Danish r and of some formant measurements of r-combinations. The possibility of describing /ɛ, œ/ after /r/ as ultra-short diphthongs is discussed.

1. Introduction

There are, in modern Standard Danish, two types of r-sounds. One is generally described as a comparatively fricative, unrolled,[2] back r, which is said to occur both voiced and voiceless, the other as a comparatively vocalic r, a non-syllabic, low vocoid[3] (Andersen 1954; Fischer-Jørgensen 1962). In this paper, the two r-types will be rendered by [ʁ̞̊] and [ɐ̯], respectively, and will be termed "contoid" and "vocoid" r.

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1) I thank Hans Basbøll, Lars Brink, Eli Fischer-Jørgensen, and Jørgen Rischel for valuable help and critical remarks in connection with the preparation of the manuscript. Lars Brink has further been of great help in plotting JR's vowels in Jones' cardinal vowel diagram. Janet Gunzenhauser has suggested many valuable improvements of my English style.

2) Lars Brink suggests (personal communication) that Danish contoid r should be regarded as a kind of vibrant, which, unlike ordinary vibrants, has rapid and irregular vibrations accompanied by friction.

3) The concepts "vocoid" and "contoid" are used as suggested by Hjelmslev 1954 (who uses them almost as Pike 1943). A vocoid is thus a voiced, non-lateral, non-nasal, frictionless, continuant sound, that may be syllabic or non-syllabic. A contoid is any other sound.

At an earlier period, there was only one type of *r*-sound, the contoid *r*. Vocoid *r* is the result of a weakening of the fricative *r* in postvocalic position. For details of this development, see Brink and Lund (1975) and section 3.1 below. In phonological descriptions, the two types of *r*-sounds are generally regarded as members of the same phoneme (e.g. Andersen 1954; Basbøll 1969). Lars Brink has argued, however, that contoid and vocoid *r* are, in fact, commutable, and that they should therefore be described as separate phonemes (personal communication). For arguments in favour of this opinion, see section 3.1 below.

The Danish vowel system has been strongly influenced by the existence of the *r*-sounds, partly because a number of vowels have been lowered/retracted before or after *r* (e.g., the vowels in words like *tres*, *skrift*, earlier pronounced [d̥ʁ̥es, sɡ̊ʁefd̥],[1] are now pronounced [d̥ˢʁ̥æs, sɡ̊ʁæfd̥] by young people); partly because earlier [ɑ] has been preserved after contoid *r* (e.g., *raske* [ʁɑsɡ̊ə]), while in other cases, it has developed into [a] before coronal (i.e., dental, alveolar, and alveolo-palatal) sounds and zero (e.g., *aske* [asɡ̊ə]); and, finally, because *r* in some cases has merged with the preceding vowel, which has resulted in the addition of two more vowel phonemes (/ɑ ɒ/) to the inventory, cf. *ane* [æːnə] vs. *Arne* [ɑːnə], and *åle* [ɔːlə] vs. *årle* [ɒːlə]. Formerly, a discrete *r* was pronounced after the vowel in words like *Arne*, *årle*, so that the vowels in word pairs like *ane* and *Arne* could be regarded as bound variants.

The purpose of the present paper is to contribute to the description of Danish *r*, both contoid and vocoid, and of the adjacent short stressed vowels. In section 3, the main distributional peculiarities concerning *r* and adjacent short vowels will be given. The consequences of the distributional pattern for the phonological description will be touched upon, but it is not my intention to go into a detailed discussion of Danish phonology. In section 4, some acoustic data about *r* and adjacent vowels taken from sonagrams will be given.

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1) For the values of the vowel signs, see below.

The kind of Danish described in this paper is approximately the same as that which Basbøll (1969) calls Advanced Standard Copenhagen. Thus, forms that are correlated with either relatively high age, relatively low socio-economic class, or some specific region in Denmark are excluded, which is not to say that everything that does lie within the chosen norm is treated exhaustively.

The phonetic notation used is that of IPA', except for the following modifications:

Primary stress is shown by acute accent (but not all cases of primary stress are indicated). A non-syllabic vowel is rendered by [̯] under the vowel sign, e.g., [e̯]. The following vowel signs have for practical reasons been redefined: [e, ø, o] = IPA [e˔, ø˔, o˔]; [ɛ, œ] = IPA [e˕, ø˕]; [æ, Œ] = IPA [ɛ, œ], [a] = IPA [ɛ˕]; [ɑ] = IPA [a-]; [ɔ] = IPA [ɔ+˔]; [ʌ] = IPA [a-˒] (thus [ʌ] is used as a sign for a (slightly) rounded vowel); [ɒ] = IPA [ɒ˔]. When diacritics are used, they refer to the above mentioned vowel values. Thus [Œ̞] = IPA [œ˕]. The signs [ä] and [Œ̈] are used as signs for the vowel segments in words like rem, træt and drøm, rønne respectively, without indicating any specific phonetic values; thus the sign [¨] does not in this paper have the traditional IPA-value "centralized". When the precise quality is not under discussion, the signs [ɩ̯] and [ɷ̯] are used for the second components in "i-" and "u-diphthongs" respectively, i.e., in words like vej, støj, and syv, hav (noun) [vɑɩ̯', sd̥ʌɩ̯', syɷ̯', hɑɷ̯], disregarding the precise values. [ɩ] and [ɷ] are used for the corresponding syllabic sounds, i.e., for the last sound in words like veje, støje, løbe, have [vɑɩ̯ɩ, sdʌɩ̯ɩ, løɷ̯ɷ, hæɷ̯ɷ] (provided that they are not pronounced with [ə]). [ɩ] and [ɐ] are undefined with respect to lip position. As the "stød"-sign, ['] is used, as recommended by IPA; [?] has the usual value, "glottal stop".

2. Earlier descriptions of Danish *r*

2.1. Contoid *r*

Jespersen (1906, translations mine) describes Danish voiced contoid *r* as follows: "... the root of the tongue is retracted, so that a slit is formed between it and the uvula or (and) the pharyngeal wall. The velum is closed and blocks the nasal cavity, but the uvula, which is generally totally inactive, may now and then, especially in formal speech, start vibrating ... The vocal cords vibrate" (p. 79). He compares contoid *r* to [ɣ] and states: "thus *r* ... in ordinary Danish pronunciation only differs from [q][1] ... in being formed farther back in the mouth ..." (p. 37). About unvoiced *r* he says: "Our *r* is in most instances voiced, but it becomes voiceless ("pustet") [ɼ̥][2] ... after *p*, *t*, *k*, *f*, thus *prise* [pɼ̥i·sə][3] - [bri·sə] *brise* ..." (p. 57). These descriptions are not changed in the third edition, published in 1934.

Also Andersen (1954, translations mine) describes the place of articulation as uvular-pharyngeal and describes the articulation as follows: "While by the related slit-shaped velar approximant [ɣ] all of the back of the tongue is raised high towards the soft palate, the movement is in the case of [ʁ] restricted to the rear part of the tongue, which is but slightly raised, rather being pushed backwards towards the pharyngeal wall and the uvula, while at the same time the rear palatine arches are drawn together horizontally, so that the opening, as opposed to the flat slit in the case of [ɣ], here approaches the shape of the tube (groove)" (p. 349). As for the degree of constriction, he says: "the Danish [ʁ] is unrolled and very lax and open" (ibid.). Also Fischer-Jørgensen (1962) describes the place of articulation as uvular-

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1) = IPA [ɣ]

2) = IPA [ʁ̥]

3) More correct (in Jespersen's notation) would be [bɼ̥i·sə]. See below, section 3.1.

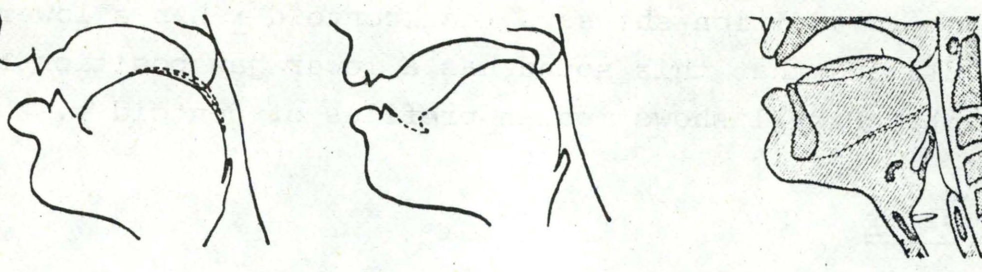
pharyngeal and mentions the contraction of the rear palatine arches, but in addition she says that contoid r has a lowering of the uvula and that this sound has a lower jaw position than [ɣ] (p. 75). Fig. 1 shows median profiles of contoid r.

2.2. Vocoid r

Under the heading "Central Vowels", Jespersen (1906, p. 85) describes the vocoid r as "... a 'vocalic r' that is distinguished from the consonants by greater distance between the tongue and the pharyngeal wall and the velum and altogether by more lax muscle activity". Grove (1927) draws the logical conclusion from this and describes (monosyllabic) vowel plus vocoid r as a diphthong. According to Grove, the lip position is determined by the surrounding sounds; he describes the movement from vowel to vocoid r as a movement towards [ɒ] (after rounded vowel) or [ɑ] (after unrounded vowel). Also Diderichsen (1957), Basbøll (1973) and Heger (1975) describe the connections of short vowel plus vocoid r as diphthongs; Basbøll and Heger mention that the lip position is determined by the surrounding sounds. Basbøll describes the gliding as directed towards a low back vowel, while Heger and Brink and Lund (1975) describe the end point as a central vowel, except for the speech of older people. Andersen (1954) describes the vocoid r as "a pharyngeal vocoid, appr. = [ɒ]" (p. 349), but as he sometimes uses the sign [ʁ] for vocoid r, a sign that is undefined with respect to lip position, he probably does not consider vocoid r to have fixed lip rounding.

3. Distributional description

It was mentioned above that the two types of r-sounds are traditionally regarded as allophones of the same phoneme. It is not my intention to discuss the validity of such an analysis.



a b c

Figure 1

Contoid r; tracings from X-rays. a and b: contoid r as spoken between low back vowels by two different subjects (after Fischer-Jørgensen 1962). c: after Forchhammer 1942.

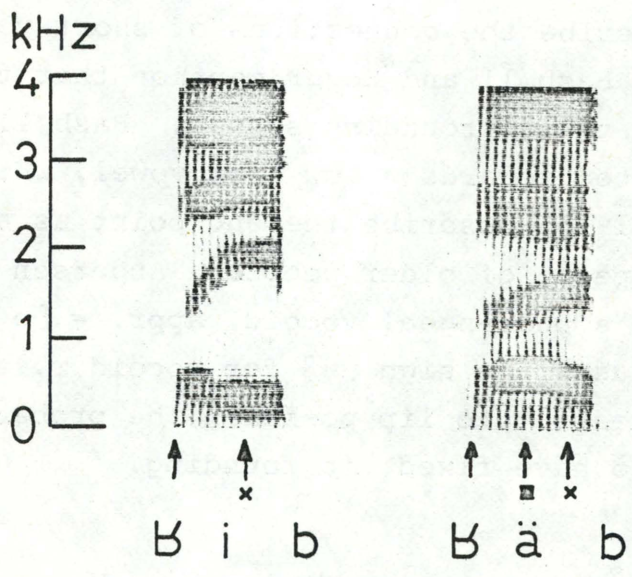


Figure 2

Examples of points of measurement in relation to the time scale in words with contoid r. Arrows: beginning of formant transitions from r to vowel ("contoid r"); crosses: F2-maximum; square: F1-maximum. The words are rippe and repsen (as spoken by the author).

I shall confine myself to a presentation of the main distributional properties of the two types of *r*-sounds, especially those which have consequences for the way in which the phonological analysis is carried out. Further, the (phonetically) short stressed vowels occurring adjacent to *r*-sounds will be enumerated. The rules given below all have the word as their "domain", i.e., they only concern utterances consisting of one word.

3.1. Distribution of the *r*-sounds

The most important limitations of the distribution of the two kinds of *r*-sounds are the following:

(i) contoid *r* only occurs immediately before a vowel

(ii) vocoid *r* only occurs immediately after a vowel.

A "vowel" is here to be understood as a syllabic vocoid. As [ð˞] is a vocoid in Danish, [ð̩˞] is included among the vowels.

The two *r*-types are further limited in their distribution with respect to the individual vowels and consonants. Concerning vowels, see section 3.2 below. Concerning consonants, the following limitations for contoid *r* can be mentioned:

(iii) when [ʁ] occurs in word-initial groups, it is always preceded by [b̥, d̥, g̊] or [v], e.g. *brise*, *dråbe*, *gris*, *vred*;

(iv) [ʁ̥] only occurs after [b̥, d̥^{s}, g̊] or [f], e.g. *prise*, *tro*, *krat*, *fred*;

(v) word-initially, [ʁ̥] does not occur in three-consonant groups.

The occurrence of initial contoid *r* can thus be summarized in the following formulae:

(a) ({(s){b̥, d̥, g̊}, v}) ʁ [+syllabic]

(b) {b̥, d̥^{s}, g̊, f} ʁ̥ [+syllabic]

Note that [ʁ] and [ʁ̥] have overlapping distribution, as both occur after [b̥] and [g̊], and that they accordingly are commutable. Compare also minimal pairs like prise - brise, krigs - gris [b̥ʁ̥i:sə - b̥ʁi:sə, g̊ʁ̥i:'s - g̊ʁi:'s].[1] In most phonological descriptions, this difference between [ʁ̥] and [ʁ][2] is regarded as a manifestation of the difference between /p/ and /b/, /k/ and /g/ respectively (/pri:sə, bri:sə; kri:'s, gri:'s/).

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1) "Vowel with 'stød'" is written [V:'] where [V] stands for any vowel sign. This notation is to be understood as [VV̯'], thus [i:'] = [ii̯'].

2) Eli Fischer-Jørgensen points out (personal communication) that r may be voiceless after b, d, g; she prefers to describe the difference between pr and br etc. as one of aspiration. In this connection I should like to draw attention to the difference between what I shall tentatively call "breathed" sounds and voiceless sounds. Voiceless sounds are sounds without vibration of the vocal cords; e.g., [s], [d̥], and [h] are voiceless sounds. Breathed sounds are sounds with a comparatively large air flow through the glottis; the air flow must be greater than that of ordinary voiced sounds. Thus [s], [h], [ɦ], and the murmured (breathy) vowels are breathed sounds. As the properties of voicelessness and "breath" may be present or absent in a sound segment independently of each other, the following diagram may be set up:

	voiced	voiceless
nonbreathed	all voiced sounds except the murmured sounds.	voiceless stops; voiced, nonbreathed sounds during whisper; possibly some voiceless continuants, e.g. Danish r after b,d,g.
breathed	murmured vowels and the corresponding non-syllabic sounds ([ɦ]).	voiceless continuants that do not belong to the "pigeon-hole" above, e.g. [s], [h], Danish r after p,t,k.

Thus, what Eli Fischer-Jørgensen describes as an aspiration difference might also be described as a difference in the degree of air flow in the segment following the stop. Of course, the two r-sounds, the breathed and the nonbreathed r, are commutable anyway. Note that voiceless continuants are generally understood to be breathed. As there is no appropriate symbol for voiceless but nonbreathed sounds, [ʁ] will be used in this paper for nonbreathed contoid r, whether voiced or voiceless.

Traditionally, contoid and vocoid *r* are said to be in complementary distribution, so that contoid *r* occurs only in (syllable-)initial position, while vocoid *r* occurs in (syllable-) final position (e.g., Basbøll 1969). However, both [ʁ] and [ɐ̯] occur in intervocalic position, as appears indirectly from rules (i) and (ii) above, and they are, accordingly, *not* in complementary distribution.

Firstly, the two *r*-sounds occur in intervocalic position conditioned by word conjunction, either in utterances with more than one word, or in compounds. Consider, for example, utterances like *de råber* 'They call (out)' and *han giver ål* 'He treats to eel' [ɖ̥iʁɔ̃ː'b̥ʌ, haŋɡ̊iɐ̯ɔ̃ː'l], or compounds like *iturevet* and *urafstemning* [iɖ̥ˢʰũʁæɒ'ð̩˔[1], ũɐ̯ɑɒ̯sɖ̥ɛm'neŋ]. Accordingly, it will be possible to form minimal (utterance) pairs that show the commutation [ʁ] - [ɐ̯], for instance, *Så giv rivalen fred* 'Then give the rival a little peace' - *Så giver I hvalen fred* 'Now you give the whale a little peace' [sʌ̃ɡ̊iʁivǽː'l̩nfb̥ǽð˔ - sʌ̃ɡ̊iɐ̯ivǽː'l̩nfb̥ǽð˔]. (On the other hand, the position of the word boundary, if any, will be indicated by the kind of *r*-sound that occurs, because the word boundary, according to rules (i) and (ii), must go immediately before an intervocalic [ʁ] and immediately after an intervocalic [ɐ̯].) Thus it is clear that the difference between vocoid and contoid *r* may be the only difference between two semantically different utterances, or that [ʁ] and [ɐ̯] are commutable. Of course, the fact that there *may* be a glottal stop between vocoid *r* and the following vowel in such cases does not contradict this conclusion.

Secondly, the two *r*-sounds occur in intervocalic position in simplex words (including derivatives). In most of these cases, the two *r*-sounds alternate freely, with contoid *r* being favoured by:

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1) Note that other phoneticians use the sign [æ] for the vowel in words like *tremme*, *strække*, which in this paper is rendered by [ä].

1) strong stress on the following vowel
2) articulate speech
3) a rare word
4) conservative language,

whereas vocoid *r* is favoured by:

5) weak stress on the following vowel
6) slurred speech
7) a frequent word
8) speech of the younger generation
9) the fact that the following sound is, or has developed from, [ə]
10) occurrence after a short stressed vowel.

The quality of adjacent vowels may also play a role. Note that, in some cases, [ʁ] alternates with other sounds than [ɐ̯], compare, e.g., *fyrig* [fy:ʁi, fy:ʌɪ̯], *hare* [hɑ:ʁə, hɑ:ɑ].

However, some simplex words always have vocoid *r*, even if all the factors favouring contoid *r* are present. This is the case in derivatives with the endings -*agtig* ('-like' or '-ish') or -*inde* ('-ess'). That words like *majorinde* and *storagtig*, (derived from *major*, *stor*) [maɪ̯oɐ̯énə, sd̥oɐ̯ɑ̊́ɡ̊d̥i] always have vocoid *r* (while words like *rigoristisk* and *professorat* (derived from *professor*) [ʁiɡ̊oʁɪ́sd̥isɡ̊, b̥ʁofɛsoʁɑ́:ˀd̥], generally have contoid *r*) cannot be predicted on the basis of the phonetic properties of the words in question.

Since the two *r*-sounds, in the cases where they have the same distribution, are not in free variation, each of them constitutes a (pre)phoneme. Therefore, any phonological description that wants to get by with only one /r/-phoneme must account in some other way for the words that have [ɐ̯] in spite of rules 1-4 above. (Probably this would be done most expediently by having a commutable syllable boundary (which we can render by /$/), which, in this connection, only occurs in words that, in spite of the above mentioned rules 1-4, always have vocoid *r*. It would, in addition, require the manifestation rule: "/r/ is always manifested as vocoid r before /$/".)

3.2. The short vowels occurring adjacent to r-sounds

3.2.1. Short vowels after contoid r

	front		central		back
	unrounded	rounded	unrounded	rounded	rounded
high	[i] Brit	[y] brynje			[u] brud
					[o] rod
	[æ] bredt	[œ] grynt			[ɔ] gråd
low	[ä] bræt	[Œ̈] grønt	[ɑ] brat	[ʌ] front	[ɒ] rov

The above table displays in order of phonetic value the (phonetically) short vowels occurring after contoid r, including an example of each possible combination of contoid r plus vowel. The combinations [ʁ̞æ, ʁ̞œ, ʁ̞ä, ʁ̞Œ̈], i.e., contoid r followed by non-high front vowel, have developed gradually from earlier [ʁ̞e, ʁ̞ø, ʁ̞ɛ, ʁ̞œ] respectively. Therefore, qualities closer to the earlier pronunciations can also be found, mostly with older speakers (Brink and Lund 1975). In the other cases, vowel quality and vowel length are not conditioned by the r.

3.2.2. Short vowels before vocoid r

	front		back
	unrounded	rounded	rounded
high	[i] svir	[y] styr	[u] turban
	[e] klaver	[ø] dør (verb)	[o] sort (adj.)
	[ɛ] hver	[œ] dør (noun)	([ɔ] åerne)
low	[æ̞] forvær	[Œ̞] forstør	

In words like <u>forvær</u>, qualities between [æ] and [a] occur. Similarly words like <u>forstør</u> have [Œ] or lower qualities. In the case of many younger speakers, there is no [ɛ] before vocoid <u>r</u>; instead, they have [æ̞]. Also [œ] before [ɐ̯] is rare with younger speakers, who thus frequently only have 3 commutable vowels in each of the front series, i.e., [i, e, æ̞] and [y, ø, Œ̞]. The occurrence of short [e, ɛ, ø, œ, ɔ] before [ɐ̯] is conditioned by the fact that earlier long [e:, ɛ:, ø:, œ:, ɔ:] (including the corresponding "stød"-vowels) have been shortened as a part of the general shortening of vowels before vocoid <u>r</u> (and the corresponding syllabic sound [ʌ]). This shortening, which is not obligatory except for the younger speakers (and even then not in all types), is much less widespread in the case of [ɔ(:)], compare [ɔ:'ʌnə] <u>åerne</u> without shortening vs. [ɔɐ̯'ʌnə]. (For a discussion of the words <u>spirrevip</u> and <u>spiritus</u>, see section 4 below.)

It thus appears that, for speakers who have both [ɛ] and [æ̞] and [œ] and [Œ̞] before [ɐ̯], there are eight commutable short front vowels and therefore eight (pre)-phonemes. As for the back series, there are three commutable vowels, but [ɔ] occurs somewhat more infrequently than the other vowels.

3.2.3. Short vowel both before and after r-sound

	front		back
	unrounded	rounded	rounded
high	[i] <u>rir</u>	[y] <u>gryr</u>	[u] <u>Ruhr</u>
			[o] <u>ror</u>
		[œ] <u>strør</u>	([ɔ] <u>råerne</u>)
	[æ] <u>rær</u>		
low		[Œ] <u>rør</u>	

The combination contoid <u>r</u> plus [œɐ̯] only occurs when [ɐ̯] is an inflexional suffix, cf. infinitive <u>strø</u> [sd̥ʁœ:'], present tense strør [sd̥ʁœːˀɐ̯, sd̥ʁœɐ̯ˀ], the last form with shortening of the vowel. As for [ɔ], see section 3.2.2 above.

4. Acoustic description

In this section, some acoustic data will be presented concerning the two types of r-sounds in Danish and their adjacent short vowels, compared with short vowels not adjacent to r. The data are based on a sonagraphic investigation of two speakers of Standard Danish. The two subjects, JR and MBL, read the following word lists (MBL did not read list no. 3):

List no. 1:	List no. 2:	List no. 3:	
hippie [hib̥i]	rippe [ʁib̥ə]	hirse [hiɐ̯sə]	/i/
yppe [yb̥ə]	krybbe [g̊ʁyb̥ə]	hyrde [hyɐ̯d̥ə]	/y/
gubbe [g̊ub̥ə]	gruppe [g̊ʁub̥ə]	urter [uɐ̯d̥ʌ]	/u/
sippet [seb̥ð̩̆ᴛ][1]	ribset [ʁæb̥sð̩̆ᵀ]		/e/
høflig [høfli]	røffel [ʁœfl̩]		/ø/
humle [hɔmlə]	rumme [ʁɔmə]		/o/
heppe [hɛb̥ə]	repsen [ʁäb̥sn̩]	herse [hæɐ̯sə]	/ɛ/
ømme [œmə]	rømme [ʁɶ̈mə]	ørken [ɶɐ̯g̊ŋ̍]	/œ/
oppe [ʌb̥ə]	rubber [ʁʌb̥ʌ]		/ɔ/
haste [hasd̥ə]	raste [ʁɑsd̥ə]		/a/
hapse [hɑb̥sə]	rapse [ʁɑb̥sə]		/a/

The phonetic transcription above is not a reproduction of the way the two speakers read the lists, but rather a kind of "standard transcription". List no. 3 only contains words whose short vowels are not short due to the above-mentioned shortening before vocoid r. The three word lists were read three times by JR, who was born in 1934 and speaks standard Danish (somewhat conservatively for his age). Lists no. 1 and 2 were read twice by MBL, who was

1) Some people pronounce this word with an [i] which, however, was not the case for these two subjects.

born in 1930 and also speaks standard Danish. Both subjects are males (and phoneticians). The recordings took place at the Institute of Phonetics, University of Copenhagen, with professional equipment. Sonagrams, both narrow and wide, were taken of all the words.

According to traditional phoneme analysis, Danish has 10 short vowel phonemes, of which /e, ø, ε, œ/, and /a/ before coronals and zero, have clearly different allophones after contoid *r*, while the other phonemes have practically the same vowel quality after contoid *r* as in other positions. The word list above indicates which vowels are generally regarded to be allophones of the same phoneme. Earlier, the allophones after contoid *r* had the same quality as in other positions, so that the present-day difference between the qualities of /e, ø, ε œ/, and /a/ before coronals, in the position after contoid *r* and their qualities in other positions is caused by the contoid *r*. The influence of contoid *r* has resulted in a lower and/or more retracted quality after *r* than in other positions. Similarly, vocoid *r* has caused a lowering of earlier [ε, œ] to the present-day [æ̞, Œ̞] in words like *herse*, *ørken*. On the other hand, earlier [e, ø] before vocoid *r*, e.g., in *hirse*, *hyrde*, has been raised to modern [i, y]. (The words *spirrevip* and *spiritus* may, however, retain [e], probably for reasons of vowel harmony.) Vowels whose quality is relatively low and/or retracted due to the presence of an *r*-sound will hereinafter be termed "*r*-coloured vowels".

It will be seen that the word lists permit the following kinds of comparisons:

1) *r*-sounds occurring after/before different adjacent vowels may be compared (e.g., [ʁ] in *rippe* (/ri../) and [ʁ] in *ribset* (/re../) or [ɐ̯] in *hirse* and [ɐ̯] in *herse*);

2) A vowel adjacent to r may be compared with the "same" vowel in other positions (e.g., [i] in rippe and [i] in hippie or [i] in hirse and [i] in hippie);

3) r-coloured vowels may be compared to the corresponding "un-coloured" vowels (e.g., [æ] in ribset and [e] in sippet or [æ̞] in herse and [ɛ] in heppe).

The sonagrams were measured in order to determine the formant frequencies. The intention was to measure the formant frequencies at the points that corresponded to the articulatory target position of the vowels and the r-sounds. In words from list no. 1, the vowel was measured at the beginning of the vowel segment (except in gubbe and sippet). The points of measurement in words with contoid r are examplified in fig. 2, where a dot denotes a point of measurement. It was not possible to measure the target position in the case of contoid r because there was not sufficient energy present; instead measurement was made at the beginning of the transition to the vowel. (In the cases where F3 begins later than F1 and F2, it was not measured at all.) The vowel after contoid r was measured at the F2-maximum, on the assumption that the target position in these cases could neither be earlier in the vowel segment if F2 was still rising, because a rising F2 is generally regarded as an indication that the tongue is being advanced (disregarding an opening at the lips, which cannot take place in these cases), nor later in the vowel segment, because the only factor that could cause a lowering of F2 is the on-glide to the following labial sound. The possibility that a simultaneous advancing of the tongue and closing at the lips might cause the F2-maximum to occur too early in the segment and/or to be too low in relation to the articulatory target position of the tongue exists, but it is only likely in the cases where the target position of the vowel is far away from that of contoid r, i.e., when r is followed by high front vowels, and in these cases the F2-maximum actually occurs comparatively late in the vowel segment (compare fig. 2). It was in order to ensure that there was an F2-maximum that the words in list no. 2 were chosen with a labial consonant after the vowel.

In words like ribset, røffel, repsen, rømme, i.e., in cases of non-high front vowel after contoid r, the transitions from r to F2-maximum do not consist of concurrent movements of F1 and F2, since F1 rises from r to a maximum that is attained earlier than the maximum of F2 (see fig. 2). In these cases, measurements for JR were also made at the F1-maximum.

In words from list no. 3, the vowel was measured at the beginning of the vowel segment, while vocoid r was measured at the F1-maximum.

4.1. The results

The numerical results appear from table 1 (JR) and table 2 (MBL). In both cases, the tables contain the average values. The standard deviations have not been calculated, but the dispersion for JR was about 25-75 Hz (except for one instance, where it was 175 Hz). For MBL, the dispersion was of a similar extent. In fig. 3, the values for JR, lists no. 1 and 2, have been plotted in the usual F1-F2 diagram. In these and the following F1-F2 diagrams, a dot indicates the values for the measurements in list no. 1; a cross indicates the values measured at the F2-maximum in words from list no. 2, a square values measured at the F1-maximum; the values measured at the beginning of the vowel transitions in words from list no. 2 (i.e., the beginning of the transitions from contoid r) are connected with the other values by an unbroken line; "r" is thus indicated by the right-hand end-point of this line. The measurements in the words hapse and rapse, i.e., /a/ before [b̥], have been omitted from the diagram. Note that, in fig. 3, all F1-values connected with /a/ have been increased (arbitrarily) by 50 Hz in order to avoid a crossover of lines.

TABLE 1

Formant values for JR

	List no. 1			List no. 2						
				"[ʁ(̥)]"		vowel				
						F1-max.		F2-max.		
	F1	F2	F3	F1	F2	F1	F2	F1	F2	F3
/i/	242	2208	3008	375	1375			300	2075	2633
/y/	250	1833	2033	350	942			325	1608	2075
/u/	275	808		333	625			325	642	
/e/	367	1950	2542	458	1275	592	1433	475	1675	2358
/ø/	350	1558	2017	475	850	500	1092	433	1375	2067
/o/	458	875		417	658			450	792	
/ɛ/	442	1933	2583	550	1258	708	1417	642	1617	2383
/œ/	425	1425	1983	492	817	652	1233	592	1350	2158
/ɔ/	675	1142	2383	500	825			633	950	
/a(s)/	658	1533	2400	592	1067			767	1325	2483
/a(b)/	725	1392	2467	575	1125			725	1142	2475

List no. 3

	vowel		[ɐ̯]		
	F1	F2	F1	F2	F3
/i/	275	1950	467	1400	2267
/y/	250	1825	475	1267	2117
/u/	250	692	483	1050	2158
/ɛ/	525	1658	700	1167	2233
/œ/	467	1392	617	975	2067

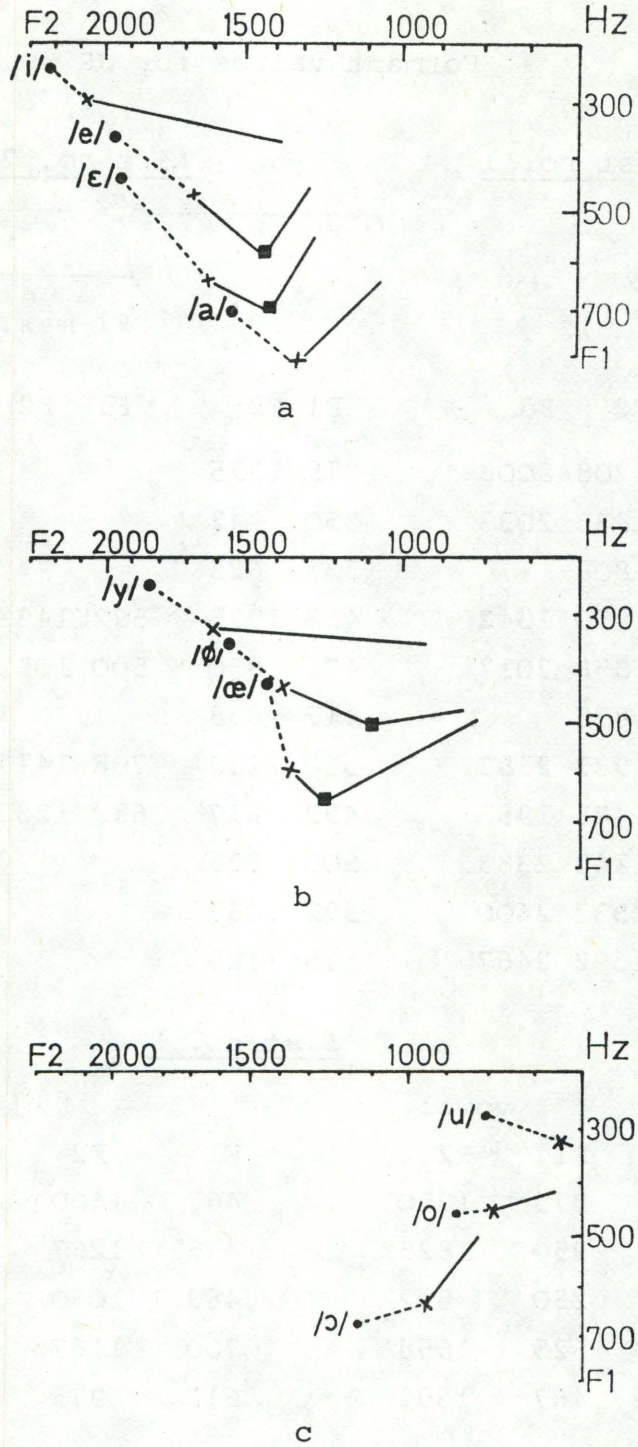

Figure 3

(Text, see opposite page)

Figure 3 (opposite page)

F1-F2 diagrams showing the beginning of vowel transitions from contoid r, as well as vowels after contoid r compared to vowels not adjacent to r. Right-hand end-point of solid lines: beginning of transitions from contoid r; squares: F1-maximum (if any) in the vowel segment following contoid r; crosses: F2-maximum in the vowel segment following contoid r; dots: vowels not adjacent to r, i.e., vowels in words from list no. 1. The values from the words hapse and rapse are omitted from the diagrams. Note that all F1-values found in words with /a/ are increased by 50 Hz in order to avoid a cross-over of lines. Subject: JR.

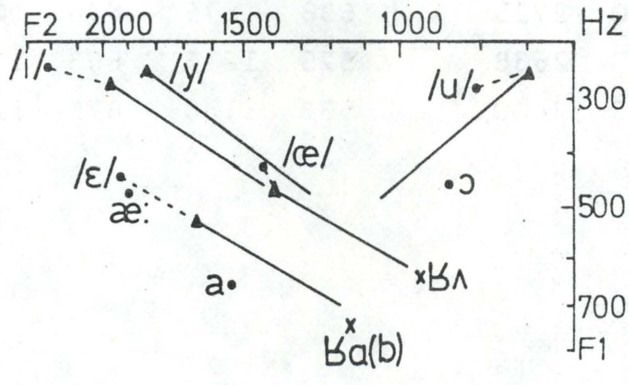

Figure 4

F1-F2 diagram showing vowels before vocoid r compared to vowels not adjacent to r, as well as vocoid r. Triangles: vowels in words with vocoid r; dots: vowels in words from list no. 1, i.e., vowels not adjacent to r; lower end-point of solid lines: vocoid r. In order to facilitate a comparison, some other vowel qualities are plotted, namely the quality of long [æ:] (as in hale) and the qualities in haste, rapse, rubber and humle. Subject: JR.

TABLE 2

Formant values for MBL

	List no. 1			List no. 2				
	vowel			"[ʁ̥]"		vowel (F2-max)		
	F1	F2	F3	F1	F2	F1	F2	F3
/i/	263	2375	3013	425	1238	375	2063	2663
/y/	238	1975	2213	375	1000	313	1613	2288
/u/	250	875		363	675	288	700	
/e/	300	2200	2813	525	1288	400	1963	2450
/ø/	300	1650	2213	475	838	375	1425	2313
/o/	338	900		350	650	438	825	
/ɛ/	363	2250	2863	663	1225	725	1863	2463
/œ/	325	1638	2300	538	775	688	1500	2438
/ɔ/	663	1250	2725	638	875	688	1088	2625
/a(s)/	700	1663	2638	575	1213	663	1325	2075
/a(b)/	775	1525	2400	538	1188	675	1275	2088

4.1.1. Contoid r

As appears from tables 1 and 2 and from fig. 3, F1 begins in the area 325-675 Hz. In the case of the three high vowels [i, y, u], F1 begins with a higher frequency than that of the following vowel, i.e., F1 falls from r to the vowel, while, in the case of the non-high vowels, it begins relatively low and then rises. This is also true for MBL. (Also in the case of MBL's contoid r plus /e/ and /ø/ there are examples of an F1-maximum before the F2-maximum, although they do not appear from table 2.) In all cases, F2 begins with a lower frequency than that of the following vowel. It was often difficult to measure F3 because of lack of intensity, particularly in the back vowels. Before [i, æ, ä], F3 begins in the area 2100-2475 Hz, depending on the F3-value of the vowel; before [y, œ], F3 begins at about 2250 Hz.

4.1.2. Vowels after contoid r

In fig. 3, a solid line connects values found in words with contoid r, while a dotted line connects a vowel from list no. 2 (after r) with the corresponding vowel from list no. 1 (after other consonants). This is justified by the fact that those vowels connected by dotted lines are traditionally regarded as having (almost) the same vowel quality (which is the case for /i, y, u, o, ɔ/), or that they at an earlier time had the same quality, but have been changed under the influence of contoid r (which is the case of /e, ø, ε, œ/, and /a/ before coronal and zero). It will be seen that the vowel occurring after r (marked by a cross) in all cases is different from the corresponding vowel from list no. 1 (marked by a dot), including those vowels which are traditionally regarded as having the same quality. In the case of rounded back vowels and the high vowels (/i, y, u, o, ɔ/), the difference is simply that the vowel after r is closer to r. In the case of the other vowels, the difference is that the vowels after r (the r-coloured vowels) have a higher F1 and a lower F2, a difference that generally corresponds to a lower and/or more retracted tongue position. In the case of /e, ɛ, œ/, the higher F1 cannot be explained on the basis of the formant values for r, since r's F1-value in these three cases is lower, cf. fig.s 3a and 3b. For all four non-high front vowels, the difference can, however, be explained as an influence from the F1-maximum (marked by a square), occurring in the vowel segments in question.

It still remains to be explained why the F1-maximum has such a high value for /e, ɛ, œ/. This may be an automatic and unavoidable effect of the movement of the tongue from the r-position to the vowel, even when this movement is the shortest possible and/or most direct one, or it may be caused by a diphthongal movement of the tongue from the r-position through an (audibly) lower vowel position than necessary. Since the concept "diphthong" denotes a perceptual phenomenon (as do many other phonetic concepts), the possibility of a diphthongal interpretation of the formant movements in question cannot be discussed without referring to the auditory impression of one or more persons.[1] A few Danish phoneticians, including the present

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1) It seems indisputable that the above-mentioned complex formant movements from r to the target values of the following vowel may be caused by a corresponding diphthongal movement of the tongue. On the other hand, it is also possible that such complex formant movements might arise as a consequence of a non-diphthongal tongue movement; but I am not at present in a position to determine whether the complex formant movements in the present material could be caused by a non-diphthongal tongue movement (Fant 1960, which contains information relevant to the discussion, does not allow for any specific conclusions concerning this issue). In any case, even if it could be shown that the complex formant movements might be caused by a non-diphthongal tongue movement, only perceptual evidence would be decisive in order to settle the discussion about the appropriate analysis of the pronunciations in question, i.e., whether they contain diphthongs or not.
Note, incidentally, that Delattre 1971 has found in a number of languages with consonants related to Danish contoid r, instances of a complex tongue movement between vowel and consonant.

writer, perceive the vowel segments in [ʁ̥ä]- and [ʁ̥Œ̈]-combinations as diphthongal and closely related to the Danish diphthongs [ɑɛ̯] and [ʌœ̯] (as, e.g., in the words <u>rejse</u>, <u>trøjer</u>), but differing from these in that, in [ä] and [Œ̈], the second component is closer to the first, i.e., approximately [ɑa̯] and [ʌŒ̯] respectively.

However, in this connection we can mention an auditory test carried out by Peter Molbæk Hansen and Bent Møller in order to examine whether the words <u>strække</u> and <u>strejke</u> have merged in the sociolect of the lower socio-economic classes in Copenhagen.[1] When not merged, the two words are pronounced with [ʁäg̊] and [ʁɑɛ̯g̊] respectively. The two words are perceptually very close to each other, but speakers of Standard Danish have a clear commutation in spontaneous speech. A speaker who was assumed to pronounce the two words alike recorded them. They were then played back in random order in the presence of various audiences, among other a group of phoneticians (including the author), who were asked to identify the test words as either <u>strække</u> or <u>strejke</u>. It turned out that the test words could not be identified correctly with more than random accuracy: a test word was identified now as <u>strække</u>, now as <u>strejke</u>, regardless of whether it was a pronunciation of <u>strække</u> or of <u>strejke</u>. Of course, this indicates that there was no difference in pronunciation between the two words. But in our connection, it is interesting to note that as many pronunciations of the word <u>strejke</u> were identified as <u>strække</u> as the other way around. It is tempting to regard this as an indication that <u>strække</u> is also pronounced with a diphthong, for how could a word containing a diphthong regularly be heard as a word <u>not</u> containing a diphthong?

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1) For a brief, general presentation of Molbæk's and Møller's investigation, see their paper in this volume of ARIPUC (the problem of <u>strække</u> - <u>strejke</u> is not included in that paper).

4.1.3. Vocoid <u>r</u>

The numerical results for vocoid <u>r</u> appear from tables 1 and 2 and fig. 4, where a triangle indicates vowel values in words from list no. 1, and values for vocoid <u>r</u> are unmarked but connected with the values for the corresponding vowels by an unbroken line. As in fig. 3, a dotted line connects values for vowels from list no. 1 with values for vowels from list no. 3, with the justification either that the connected vowels traditionally are regarded as having (practically) the same vowel quality (which is the case of /i, y, u/)[1], or that this was earlier the case (/ɛ, œ/).

After the high vowels, vocoid <u>r</u> seems to be something like a non-syllabic neutral vocoid, [ɐ̯], while, after /ɛ/ and /œ/, it is, rather, a central <u>low</u> non-syllabic vocoid. The F3-values for vocoid <u>r</u> lie between those of the unrounded and rounded vowels, which indicates that vocoid <u>r</u> has no specific lip position, but that this may vary, depending on the lip position of the surrounding sounds.

4.1.4. Short vowel before vocoid <u>r</u>

In one case, there is no difference between the values for a vowel from list no. 1 and the values for the corresponding vowel from list no. 3, namely in the case of /y/. In the other cases, the vowel before <u>r</u> is closer to <u>r</u>, except /u/, where the vowel before <u>r</u> is farther away.

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1) As mentioned above (section 4), [iɐ̯] and [yɐ̯] have gradually developed from earlier [eɐ̯] and [øɐ̯] respectively; accordingly, there also occur intermediate qualities. Words with modern [uɐ̯] have also had a lower quality, [oɐ̯], at an earlier date. Of course, [i, y, u] before [ɐ̯] may also have developed from earlier long vowels, cf. section 3.2.2 above.

4.2. The acoustic data compared with an auditory description

In order to give the reader an idea of the more exact phonetic quality of the vowels that are described acoustically above, the vowels from JR's first reading of the lists have been plotted in Daniel Jones' cardinal vowel diagram, using two tape recorders so that Jones' and JR's vowels could be compared directly and immediately. Two different plottings were carried out by the Danish phonetician Lars Brink and the author; they were done independently of each other, and there was no later correction. They are seen in figs. 5 (Lars Brink) and 6 (Steffen Heger). The same symbols are used as in the previous figures. Thus, a dot denotes a vowel from list no. 1, a cross a vowel from list no. 2, and a triangle a vowel from list no. 3. Two crosses connected by a solid line indicate that a glide from the low to the high quality (i.e., a closing diphthong) was heard. Note that diphthongs were not heard in every case of non-concurrent formant movements, and that LB and SH differ in their descriptions of the vowel in ribset. In figs. 7a and 7b, the corresponding F1-F2 values are given.

4.3. Intervocalic contoid r

In order to make it possible to measure the F1-F2-values corresponding to the target position of [ʁ], a series of nonsense syllables consisting of vowels and intervocalic [ʁ] was spoken by the author. [ʁ] was spoken between a number of Danish vowel qualities, without any attempt to pronounce structurally possible combinations. Instead, it was attempted to attain the same vowel quality before and after r. The results appear from fig. 8, where the left-hand end-point of each line indicates the F1-F2 values for the vowel, while the right-hand end-point indicates the F1-F2 values for the corresponding r-sound.

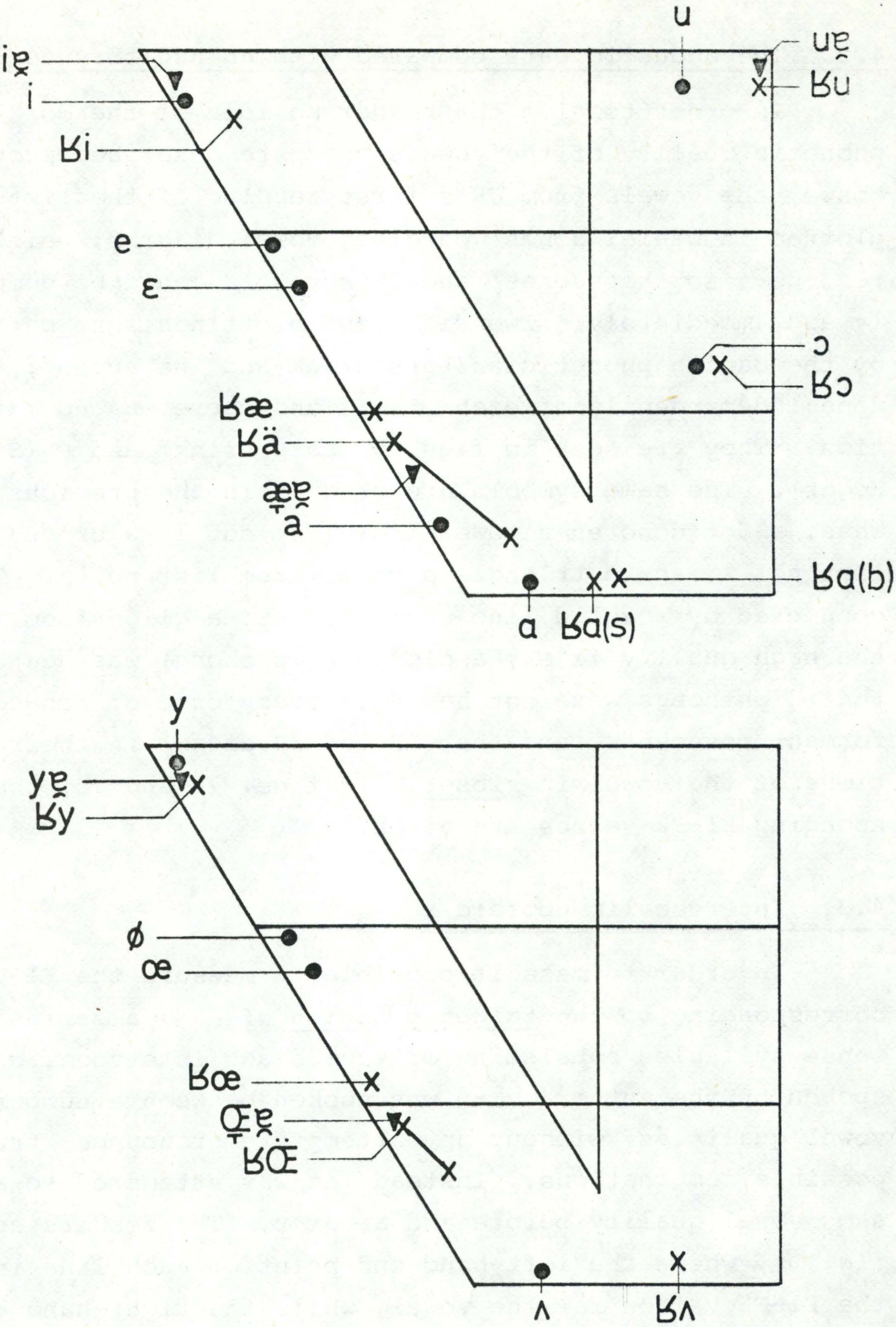


Figure 5

JR's vowels, 1st recording, plotted by Lars Brink. Note that the phonetic transcription in figs. 5-7 is the same as that of the word lists in section 4 and thus only serves the purpose of identifying the plots with the words in the word list. iɐ̯ means [i] before [ɐ̯], ʁi means [i] after [ʁ], etc. In figs. 5-6 a glide in vowel quality is expressed by two crosses connected by a line.

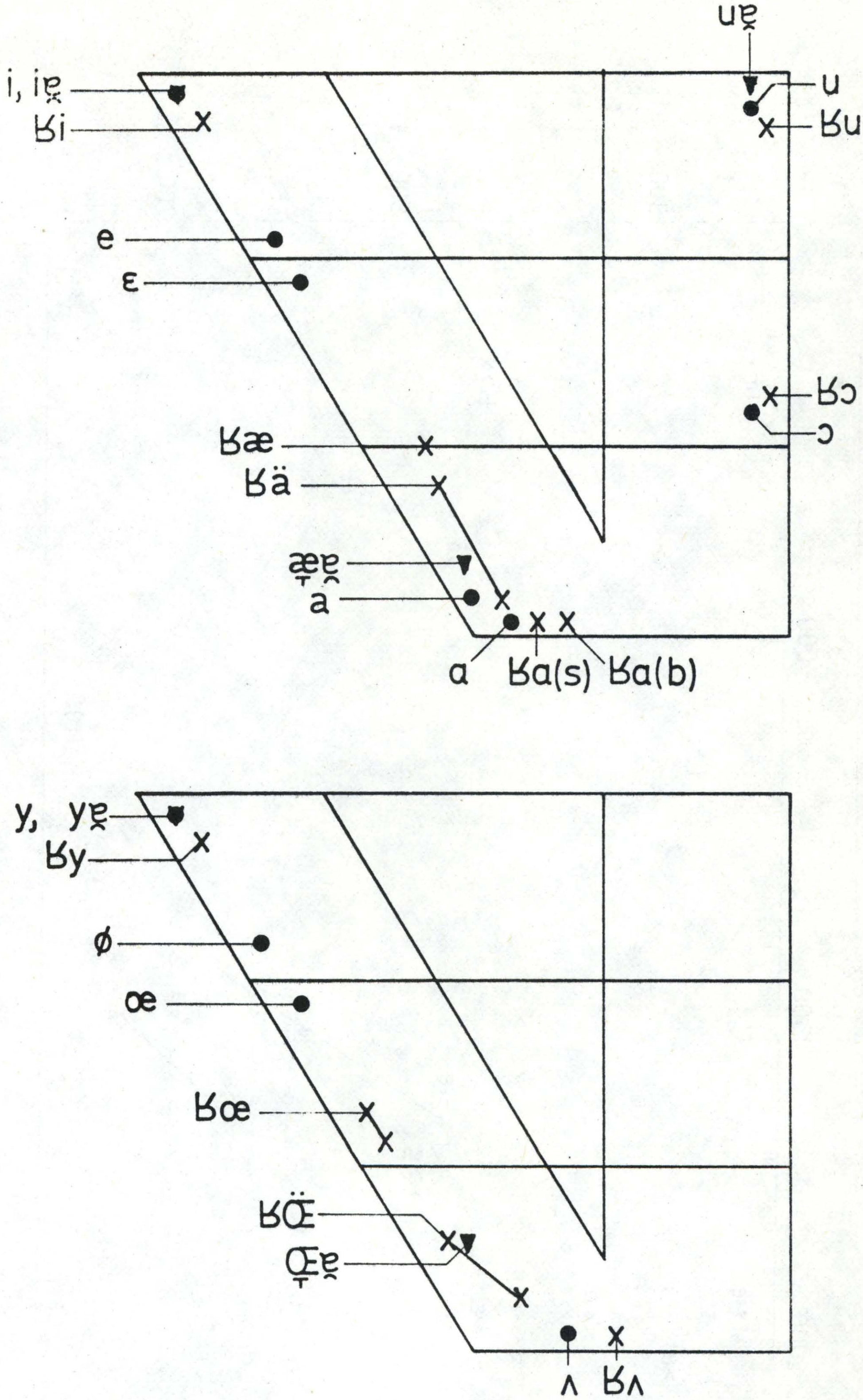


Figure 6

JR's vowels, 1st recording, plotted by Steffen Heger.

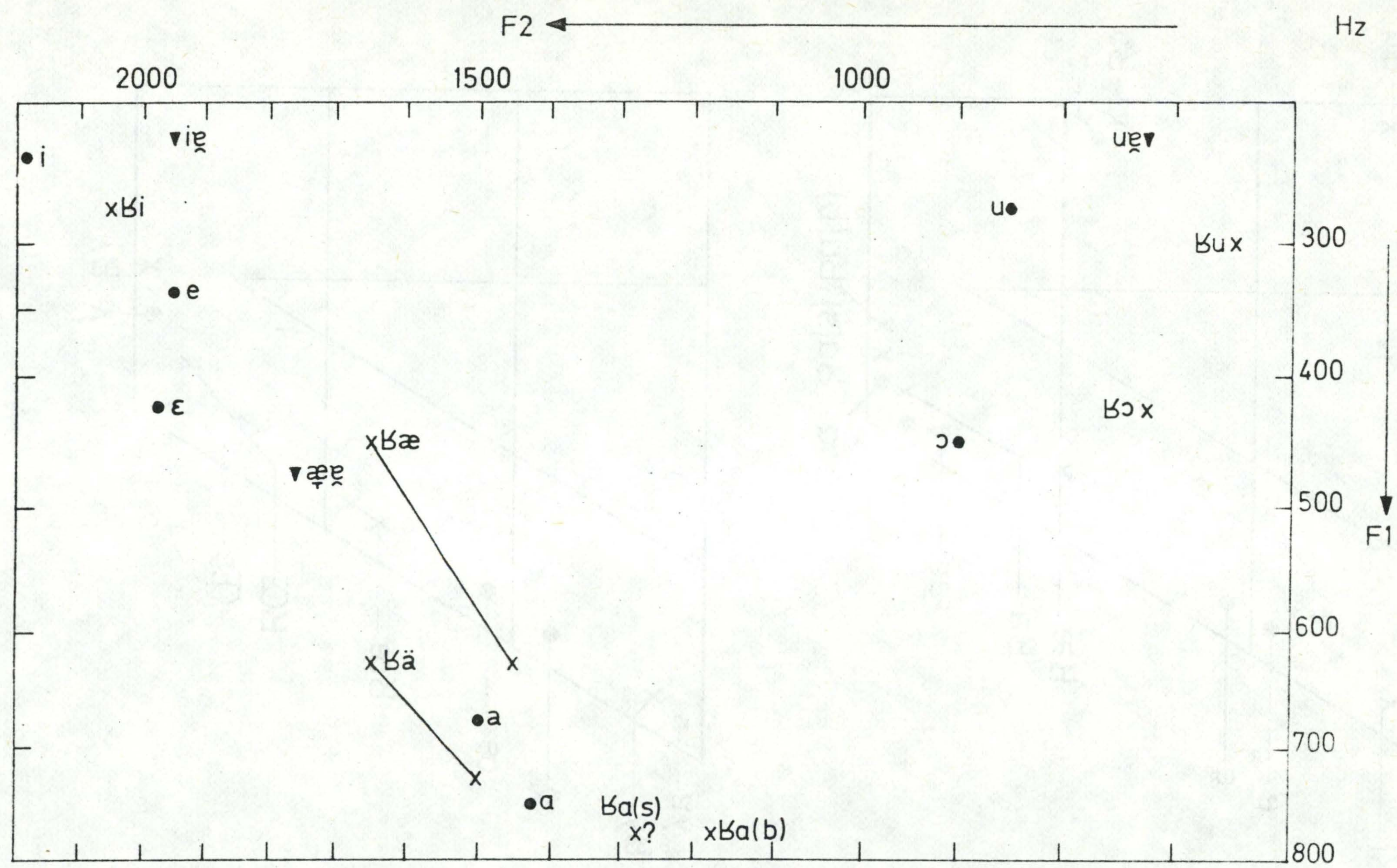
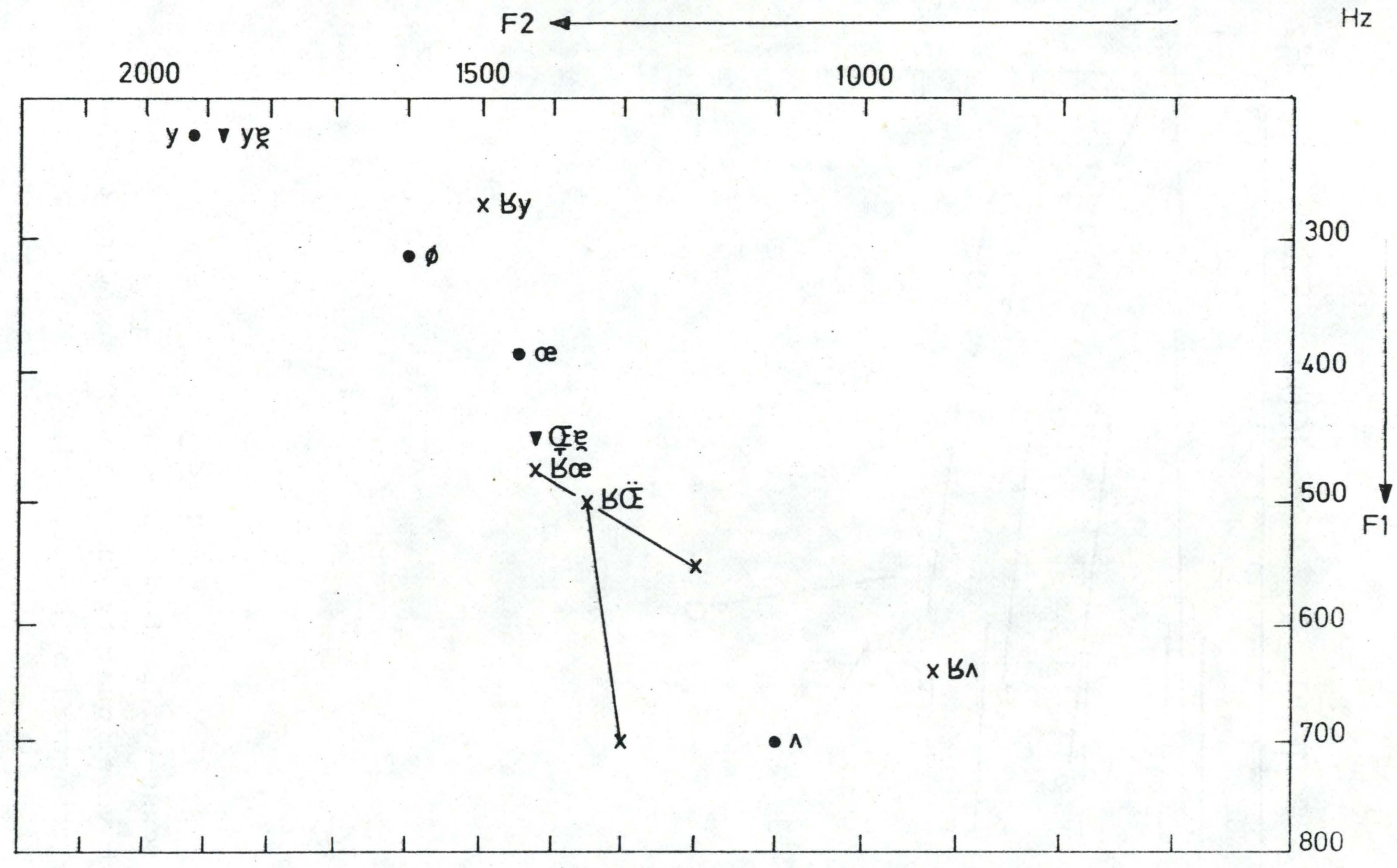


Figure 7a

JR's vowels, 1st recording, F1-F2 diagram.



<u>Figure 7b</u>

JR's vowels, 1st recording, F1-F2 diagram.
Note that there is no one-to-one correspondence between vowel segments with an F1-maximum and vowel segments heard as containing a change in vowel quality (compare figs. 5 and 6).

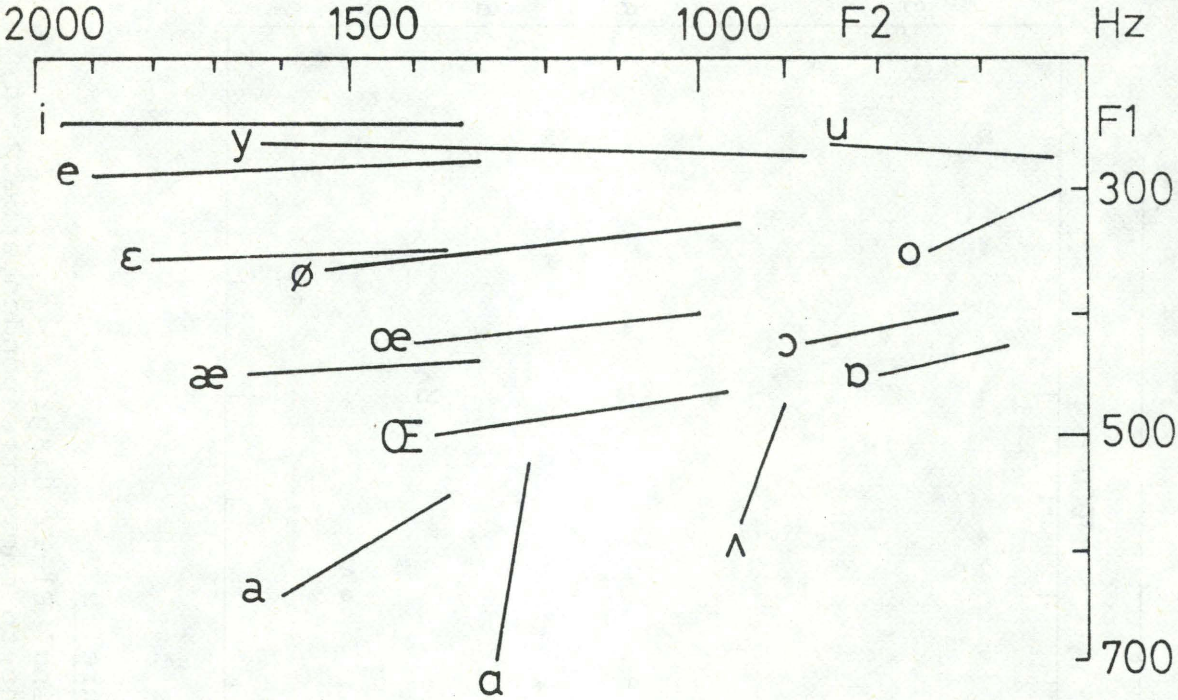


Figure 8

Nonsense-words of the type V_1+ʁ+V_1, F1-F2 diagram. Each vowel quality and the corresponding contoid r are connected by a solid line.

4.4. Additional material

Other spectrograms confirm that /e, ø, ɛ, œ/ after contoid r may show the above-mentioned non-concurrent formant movements, where both F1 and F2 rise from r and then F1 falls while F2 continues to rise (whereafter the formants move towards the "locus" of the following consonant). Thus Eli Fischer-Jørgensen has sonagrams produced by 7 male subjects who have spoken a number of words with contoid r followed by short vowel that in many cases (perhaps all; it is often difficult to determine the formant movements of the sonagrams in question) display the non-concurrent formant movements of contoid r plus /e, ø, ɛ, œ/. Recordings of final [ʁä] (in the utterance: "Jeg sagde trefod, ikke træ-") also display examples of the complex formant movements, which shows that they are not caused by the following consonant. Finally, in Molbæk Hansen and Møller's material (see their paper in this volume), with six subjects, there are four whose sonagrams display the complex formant movements before labial and alveolar (that not all six subjects have them is unsurprising, since some of their subjects were chosen because they were expected to have /ra/ instead of /rɛ/ except before velar: the investigation was done in order to cast light on the merger of /rɛ/ and /ra/, where both kinds of words are pronounced with [ʁ̞ɑ]).

5. Concluding remarks

The purpose of the present paper has been to present various phonetic data concerning r-combinations in Danish, as part of the prerequisites for phonetic and phonological analyses of the r-combinations.

There is one problem in particular which stands out as unsolved after the present investigation, viz. the question whether the vowel segments corresponding to the phonemes /ɛ, œ/

after contoid r should be described as monophthongs or diphthongs. I have given some acoustic data, but in my opinion the issue is ultimately a perceptual one.

Obviously, X-ray data on these r-combinations in Danish, as well as a deeper understanding of the relationship between perceived changes in vowel quality and formant movements, will also contribute to the solution of this problem.

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(ARIPUC 9, 1975)

THE INFLUENCE OF ACOUSTIC AND PHYSIOLOGICAL FACTORS ON SOME VOWEL CHANGES IN DANISH

Peter Molbæk Hansen and Bent Møller

1. Introduction

The investigation reported in the present article is concerned with the development of the short vowels /ɛ/ and /a/ in the Copenhagen dialect. Some of the problems discussed seem to be relevant to the study of sound change in general[1].

Our main source of historical data is a recent work by Brink and Lund on the development of the pronunciation of Danish since 1840 (Brink and Lund 1975). According to these authors, the phonemes[2] /ɛ/ and /a/ were pronounced as indicated below about 1840:

	after [ʁ]	elsewhere
/ɛ/	[æ]	[ɛ]
/a/	[ɑ]	

During the period 1840-1900 the following change gradually spread in the Copenhagen dialect (and in Standard Danish):

(1) [ɑ] → [æ] before alveolar consonants (except when preceded by [ʁ]), e.g. [nɑt] → [næt]. In idiolects characterized by (1), the distribution of allophones of /ɛ/ and /a/ after the change is as shown below:

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1) We are grateful to Eli Fischer-Jørgensen for urging us to take up this investigation and for valuable criticism.

2) The term phoneme is used in a diachronic sense here.

	after [ʁ]	elsewhere	
		before alveolars	before labials and dorsals
/ɛ/	[æ]	[ɛ]	[ɛ]
/a/	[ɑ]	[æ]	[ɑ]

This is roughly the situation in modern Standard Danish. In the Copenhagen dialect, however, the following change is reported to have spread at least since the beginning of this century:

(2) [æ] → [ɑ] after [ʁ] before alveolars,

e.g. [ʁæt] → [ʁɑt]. In idiolects characterized by (2), even the following change is gaining ground:

(3) [æ] → [ɑ] after [ʁ] before labials,

e.g. [sgʁæmə] → [sgʁɑmə]. Both (2) and (3) are favoured by the younger generation; (3) is characteristic of the lower social classes (cf. Brink and Lund 1975, vol. 1, p. 128-132).

One phonological consequence of (2) and (3) is a merger of words like /brɛnə/-/branə/ and of words like /skrɛpə/-/skrapə/, both types of words being pronounced with an [ɑ]-like vowel. No [æ]-retraction after [ʁ] is reported to have taken place before dorsals, i.e. words like /brɛk/-/brak/ have remained clearly distinguishable (being usually transcribed [bʁæg]-[bʁɑg]). In the remainder of this article we shall refer to words like /brɛk/, /rɛt/, /skrɛpə/, etc. as /rɛ/-words, and to words like /brak/, /rat/, /skrapə/, etc. as /ra/-words. Although the changes (1), (2), and (3) are obviously phonetically conditioned, some problems arise if we compare them: In (1) a back vowel is fronted before alveolar consonants, whereas in (2) a front vowel is retracted before alveolar consonants. Moreover, in (1) alveolars are opposed to labials and dorsals as regards the effect on a preceding /a/; in (3) dorsals are opposed to alveolars and labials as regards the effect on a preceding /ɛ/. Although ʁ-colouring must somehow be involved in (2) and (3), it seems difficult to explain these facts.

On this background we have concerned ourselves with the following problems: (I) Is the /rɛ/-/ra/ merger before alveolars (and labials) a true merger in the sense that no systematic acoustic differences are found between /rɛ/-words and /ra/-words in the pronunciation of speakers who appear to be representative of these mergers? (for a detailed discussion of various aspects of the concept of merger, see Labov 1972). (II) is it possible to explain the fact that /rɛ/- and /ra/-words have remained clearly distinguishable when the postvocalic consonant is dorsal? - (III) is it possible to explain the fact that the change (3) is less frequent than (2) and seems to presuppose the latter?

With the aim of contributing to a solution of these problems we have investigated the acoustic characteristics of some typical /rɛ/- and /ra/-words as spoken by five speakers of the Copenhagen dialect representing different social classes and different age groups.

2. Subjects and Material

The investigation was based upon sound spectrograms. In order to obtain an optimal ratio between the bandwidth of the spectrograph and the F_0 of the subjects, only male subjects were chosen. The subjects were:

FR
Age: 22
Occupation: craftsman (temporarily unemployed)
Social background: parents uneducated workers.

BJ
Age: 22
Occupation: craftsman (temporarily unemployed)
Social background: parents uneducated workers.

JS
Age: 39
Occupation: various jobs, now a university student
Social background: parents uneducated workers.

SN
Age: 25
Occupation: dentist
Social background: father a skilled worker, mother uneducated.

PO
Age: 22
Occupation: university student
Social background: parents university graduates.

In order to facilitate the delimitation of segments on the spectrograms we used words in which [ʁ] is preceded by (s +) an unaspirated stop and the vowel is followed by a stop or a nasal. Only mono- and bisyllabic words were used. Thus the words to be compared directly formed minimal or subminimal pairs each consisting of a /rɛ/-word and a /ra/-word. The test words are listed below in their orthographical form and in the traditional IPA transcription of Standard Danish:

skrappe	[sgʁɑbə]	skramme	[sgʁɑmə]	bratte	[bʁɑdə]
skræppe	[sgʁæbə]	skræmme	[sgʁæmə]	brættet	[bʁædəð]
brande	[bʁɑnə]	brak	[bʁɑg]	Strange	[sdʁɑŋə]
brænde	[bʁænə]	bræk	[bʁæg]	strenge	[sdʁæŋə]

The test words were placed in frame sentences according to the following criteria: (i) The syllable containing the vowels under investigation should have a full sentence stress, (ii) the words which were to be compared directly, i.e. the members of each minimal pair, should have the same placement in the rhythmical structure of their respective sentences and these sentences should be of the same rhythmical structure. Each test word should be sentence final, if possible. For instance, the words bræk and brak (/brɛk/ and /brak/) appeared in the sentences "Så gik de ud på bræk" and "Naboens jord lå brak", respectively.

In the list presented to the subjects the sentences containing the relevant words occurred in random order, and several irrelevant sentences were interspersed among them. The subjects were asked to say the sentences in a normal tempo and to make a pause between each sentence. 12 recordings were made of FR and BJ each, and 7 recordings were made of JS, SN, and PO each. The recordings were made in the recording studio of the Institute of Phonetics.

3. Spectrographic analysis and quantification problems

In order to keep the rather laborious technical treatment of the material within reasonable time limits we contented ourselves with a selection of 5 out of the total number of recordings of each subject. This selection was, of course, made at random (certain recordings, however, were immediately discarded because they were characterized by clearly unintended pronunciation phenomena: coughing, stuttering, and the like). Thus, for each subject, 5 specimens of each of the relevant words were analyzed.

Danish [ʁ] being in most instances a voiced uvular or uvulo-pharyngeal continuant with little or no friction noise, the [ʁ] + vowel phase of the words under investigation shows a continuous vocalic formant structure on the spectrograms. A preliminary series of measurements of F_1 and F_2 at the beginning of the rV-phase showed no systematic differences between corresponding /rɛ/- and /ra/-words of the same subject. It turned out, however, that F_2 at the beginning of the vocalic phase was highly sensitive to the type of consonant preceding [ʁ]. The mean values of F_2 at this point (calculated for all subjects as a whole) were 1295 cps, 1142 cps, and 922 cps in words with prevocalic [sgʁ], [sdʁ], and [bʁ], respectively. These differences must be ascribed to coarticulation effects, F_2 of [g] being higher than that of [d], and F_2 of [b] being considerably lower than that of [d]. These results (and the formant movements in general) show that the point nearest to [ʁ]-target is only reached some centiseconds after the beginning of the vocalic phase. Consequently, if there is a difference in vowel target between /rɛ/- and /ra/-words it should be noticeable only in the later parts of the vocalic phase. Since a difference between a more [æ]-like and a more [ɑ]-like vowel is mainly one of frontness vs. backness, F_2 in the late part of the vocalic phase must be most sensitive to such a difference.

In quantifying the acoustic properties of the vowel qualities under investigation we therefore looked for the point during the F_2 movement at which the influence of the vowel target is at a maximum. This point is rather well-defined in the words with postvocalic labials. Two extreme types of words within this category are shown in fig. 1. In the most [æ]-like type shown in (a), F_2 rises slightly after the [ʁ]-target. In the most [ɑ]-like type shown in (b), F2 is straight after the initial [sg]-transition (cf. above). Note that in this type there is no way of delimiting [ʚ] from [ɑ] acoustically. In all these words there is a final (short) negative transition due to the succeding labial. The formant frequencies of F1 and F2 were measured just before the final fall of F2. As both [ʚ] and labials have a lowering effect on F2, this point must be the one nearest to the vowel target.

In the words with postvocalic alveolars the point nearest to the vowel target is not always well-defined on the spectrograms. Some typical formant movements of these words are shown in fig. 2. In the most [æ]-like type shown in (a), F2 is rising after the [ʚ]-target and reaches a late, steady [æ]-state; the transition of the succeding alveolar is straight or slightly falling (as should be expected with a vowel of this type, see e.g. Fischer-Jørgensen 1954). In the most [ɑ]-like type shown in (b), F2 has a prolonged [ʚ]-[ɑ]-phase, as in type (b) of the words with postvocalic labials, fig. 1 (b). However, the transition of the succeding alveolar is positive and somewhat longer than the transition of a labial, since it reflects a tongue movement. These extreme types are thus clearly different. They are not typical, however. In most cases the F2 movement in these words is something in between the movements shown in (a) and (b), so that there is a more or less rising F2 throughout the vocalic phase in the majority of both /rɛ/-words and /ra/-words, as shown in (c) and (d). Such formant movements must reflect a continuous tongue movement from the position of a pharyngealized vowel of [ʚ]-type to the position required by the final coronal articulation. It cannot be decided, with this type of formant movement, at what point the influence of the vowel target is at a maximum. It appears from fig. 2 (e), however, that if we assume a fixed second formant locus of alveolars, a possible systematic difference in F_2 between an [æ]-target and an [ɑ]-target should imply

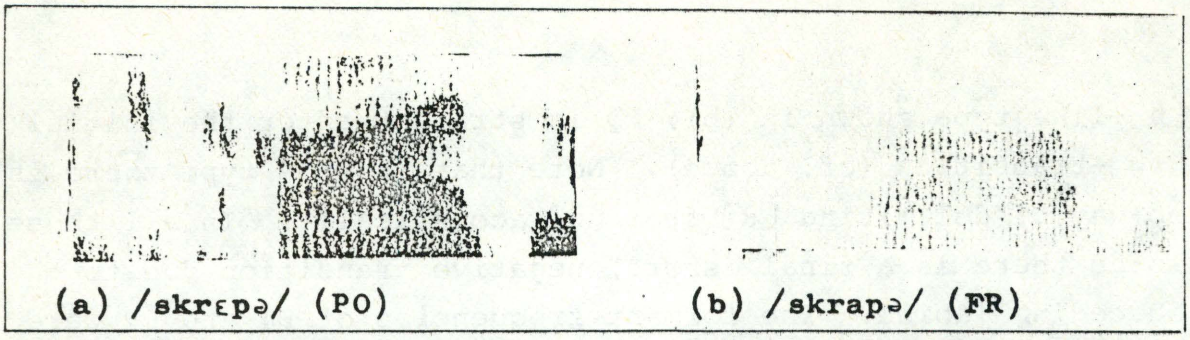


Fig. 1. Spectrograms of words with postvocalic labials, cf. text.

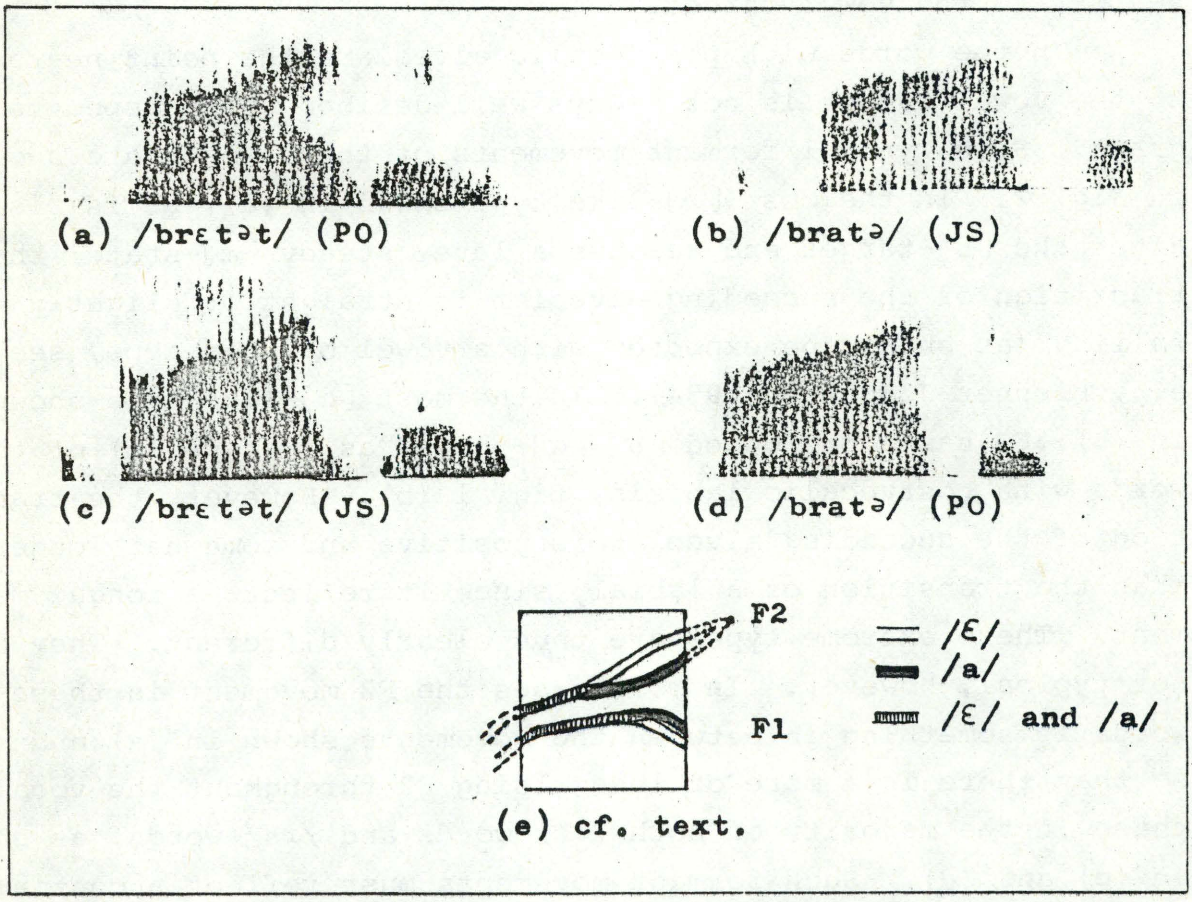


Fig. 2. Spectrograms of words with postvocalic alveolars, cf. text.

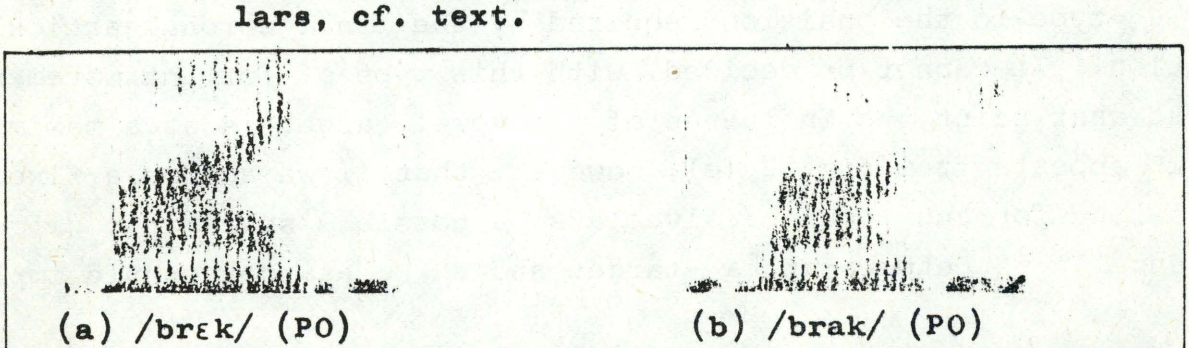


Fig. 3. Spectrograms of words with postvocalic dorsals, cf. text.

a corresponding, though somewhat less marked difference at the end of the vocalic phase. Of course, the formant frequencies at this point are highly influenced by the succeding consonant, but the influence of any intended [æ]- or [ɑ]-target should still be noticeable. We therefore measured the formant frequencies at the end of the vocalic phase in the words with postvocalic alveolars.

In the words with postvocalic dorsals there was always a directly visible difference between /rɛ/-words and /ra/-words. Typical formant movements are shown in fig. 3. There is never a steady [æ]-state in /rɛ/-words, and there is not always a steady [ɑ]-state in /ra/-words. Thus the rather marked difference in formant movements must be ascribed, at least in part, to differences between the postvocalic dorsals of /rɛ/-words and those of /ra/-words. The existence of two types of dorsals in these words is not surprising, since it is a well-known fact that Danish dorsals are very sensitive to the place of articulation of neighbouring vowels. However, this clearly audible difference between a more palatal type and a more velar type of dorsals is traditionally ignored in current types of phonetic transcription of Danish (including the DANIA system used by Brink and Lund) which are otherwise rather narrow. It is obvious that these two types of dorsals are partly responsible for the fact that no merger has taken place between words like /b^{r}ɛk/ and /b^{r}ak/ (cf. section 4 below). In the words with postvocalic dorsals we quantified the acoustic qualities in the same way as in the words ending in alveolars, i.e. by measuring the formant frequences at the end of the vocalic phase.

4. Acoustic data

4.1. General remarks

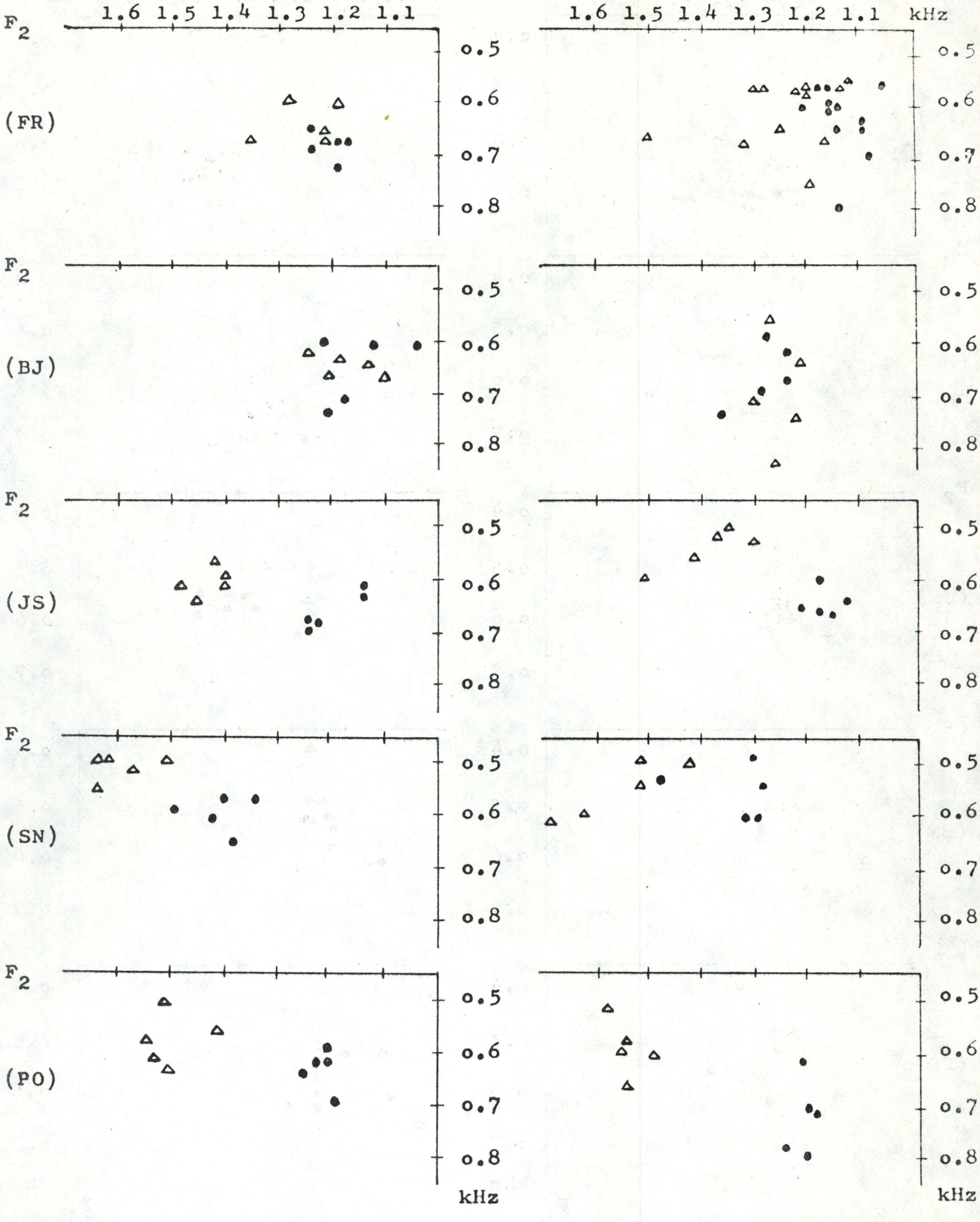
As mentioned above we analyzed 5 recordings of each word. In two minimal pairs, however, we attempted to establish a more solid judgment by analyzing a greater number of items. We thus analyzed 12 items of each of the words /skrɛpə/ and /skrapə/, and 11 items of each of the words /brɛnə/ and /branə/ of FR (we had 12 recordings of FR and BJ at our disposal). For each minimal pair the data of each subject are visualized in the F_1-F_2 diagrams on the following pages. In the diagrams each solid circle represents a /ra/-item, and each triangle represents a /rɛ/-item. It follows from the discussion of measurements that the F_1-F_2 values should not be taken to represent true vowel plots except perhaps in the words with postvocalic labials. Under the circumstances the values only represent the best approximations to the alleged vowel targets.

4.2. Results of the pairs /skrɛpə/-/skrapə/ and /skrɛmə/-/skramə/

It appears from fig. 4 that PO and JS have a clear distinction. This is also true of SN, although one of his /ra/-items is rather [æ]-like. However, an auditive check on this particular item led us to judge it as a mispronunciation. This decision is further supported by the fact that we here observe a forward movement of /a/ which is the reverse of the general tendency. BJ represents the opposite extreme with complete overlapping. The most interesting result is that of FR: Although, as one might expect, the most [æ]-like qualities occur in /rɛ/-words and the most [ɑ]-like qualities occur in /ra/-words, there is more overlapping than one would expect between phonemically different vowels.

4.3. Results of the pairs /brɛtət/-/bratə/ and /brɛnə/-/branə/

As seen from fig. 5, PO shows a relatively clear tendency toward a distinction, whereas BJ and SN show complete overlapping. FR shows no trace of any systematic difference in the pair /brɛtət/-/bratə/; in the other pair he shows a puzzling tendency



/skramə/: ●

/skrɛmə/: △

/skrapə/: ●

/skrɛpə/: △

Fig. 4 F_1-F_2 plots of vowels followed by labials, cf. text.

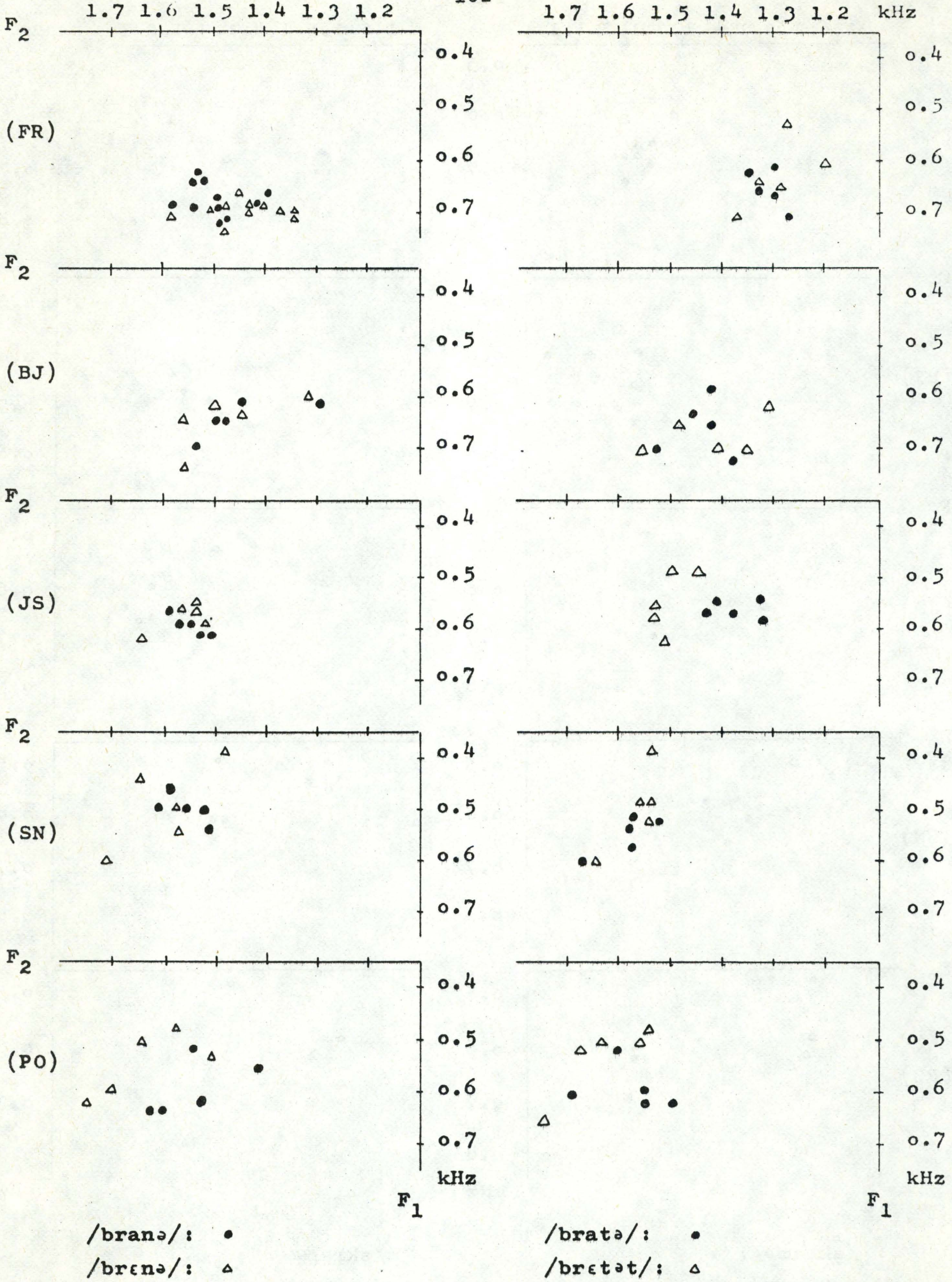


Fig. 5 F_1-F_2 plots of vowels followed by alveolars, cf. text.

to produce the most [æ]-like qualities in /branə/ and the most [ɑ]-like qualities in /brɛnə/. It should be noted, however, that /brɛnə/ and /branə/ are closely related genetically and semantically: /brɛnə/ means 'burn', and /branə/ means 'fires' (sb. pl.). It is probable that these words are felt to be identical by FR.[1] If this is true, what we have called /rɛ/-items and /ra/-items are simply items of the same statistical population. This interpretation (which is not needed to explain the cases of overlapping in general, cf. section 5 below) is supported by the data of JS who has complete overlapping in /brɛnə/-/branə/ and a clear distinction in /brɛtət/-/bratə/.

4.4. Results of the pairs /brɛk/-/brak/ and /strɛŋə/-/straŋə/

These results are not illustrated in F_1-F_2 diagrams. All subjects show a clear difference without overlapping. F_2 of /rɛ/-words is always 400-600 cps higher (at the end of the vocalic phase, cf. section 3 above) than F_2 of /ra/-words, and F_1 is generally lower in /rɛ/-words.

4.5. The results in general

As regards /rɛ/-/ra/-merger, there were no cases of discrepancy between our auditive impression and the acoustic results: whenever there was a clear acoustic difference, this difference was clearly audible. Moreover, the results are in agreement with the expected tendencies: (1) No merger before dorsals. (2) Merger before alveolars except for JS and PO (if we interpret the special behaviour of /brɛnə/-/branə/ in the speech of JS and FR as suggested above, i.e. as lexical identification); JS represents the older generation (39 years old), and PO represents the higher social classes (university student, parents university graduates).

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1) The difference between /brɛnə/ and /branə/ was originally due to the Germanic umlaut processes. Such differences are now lexicalized.

(3) Merger before labials occurs only in combination with merger before alveolars and is only represented by the lowest social classes (BJ and, less markedly, FR).

5. A simplified model of the development of /rɛ/

Although the non-merger of /rɛ/-/ra/ before dorsals seems to be connected with the existence of two types of dorsals, cf. section 4 above, the problems raised in section 1 (i.e., the different behaviour of /rɛ/ before different types of consonants, and the difference between the effect of alveolars on vowels preceded by [ʁ] and that on vowels not preceded by [ʁ]) on the whole remain unsolved. We shall argue, however, that these facts may be explained as the natural consequences of the acoustic (and articulatory) properties of the sequences involved, under the assumption that the changes were initiated by a single phenomenon, viz. pharyngealization and lengthening of [ʁ]. We shall base this explanation on the following facts: (1) In all types of idiolects the dorsal phonemes have two main allophones; a postpalatal type after (and before) front vowels, and a velar type after (and before) back vowels. It is reasonable to assume that this allophony existed prior to the vowel changes after [ʁ]. (2) Alveolars have a rising F_2-transition in a preceding [ɑ]-like vowel and a straight or slightly falling F_2-transition in a preceding [æ]-like vowel. (3) The F_2-transition of labials is negative in both [ɑ]- and [æ]-like vowels and (if at all present) rather short.

Let us consider a conservative type of the Copenhagen dialect (without any mergers) as represented by PO and JS: The formant movements during the vocalic phase of the words /brɛk/, /bṛak/, /brɛtət/, /bratə/, /skrɛpə/, and /skrapə/ are shown in a stylized version in fig. 6 along with typical spectrograms of these words from the recordings of PO. The black traces represent the formant movements of /ra/-words, the white traces represent the formant movements of /rɛ/-words, and the hatched traces represent formant movements common to both /ra/- and /rɛ/-words.

In all words there is an initial, relatively short, [ʚ]-like phase. After this phase the following happens: In /brɛk/ F_1 falls and F_2 rises sharply throughout the vocalic phase. The early part of these formant movements must reflect a continuous forward movement of the tongue towards the position of [æ]. However, there seems to be no time for any [æ]-steady state to be reached, and the tongue moves further up towards the position of the postpalatal type of dorsal to follow. In /bʀak/ there is time for a short [ɑ]-steady state (which is nothing more than a prolonged pharyngeal ʚ^{ɑ}-phase) before the final upward movement of the tongue towards the position of the velar type of dorsal to follow (as reflected by the shorter and less steep F_2-rise). Thus the difference is clear and is due partly to different vowel targets, partly to the different types of dorsals. In /brɛtət/ the tongue moves forward (and upward), causing F_2 to rise (and F_1 to fall slightly) until the intended [æ]-position is reached; there is time for a short [æ]-steady state owing to the rather independent final tongue blade articulation which does not influence the formant movements of an [æ]-like vowel (straight transitions); in /bʀatə/ the ʚ^{ɑ}-position (as in /bʀak/) is held somewhat longer until the forward movement of the tongue body required by the final tongue blade articulation causes F_2 to rise. In /skrɛpə/ and /skʀapə/ the formant movements are similar to those of /brɛtət/ and /bʀatə/, respectively, except, of course, for the final transitions of the labials which are negative and, owing to the independent lip articulation, rather short (if at all present). The /rɛ/-/ra/-difference is thus clear in all three types.

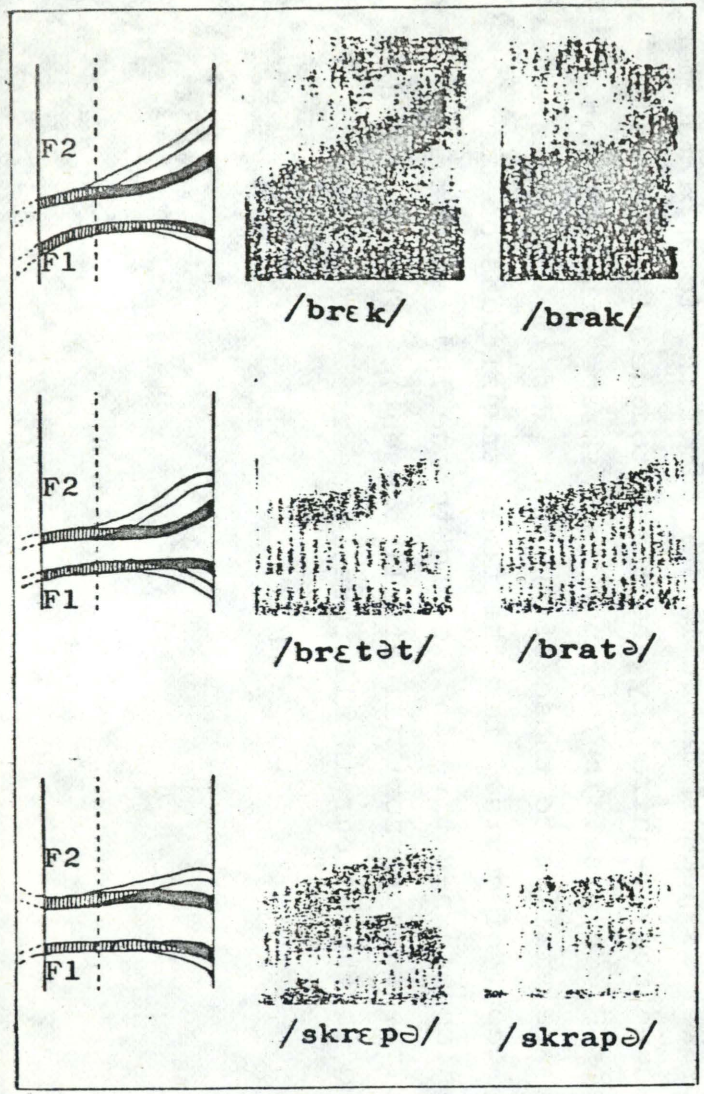

Fig. 6. PO

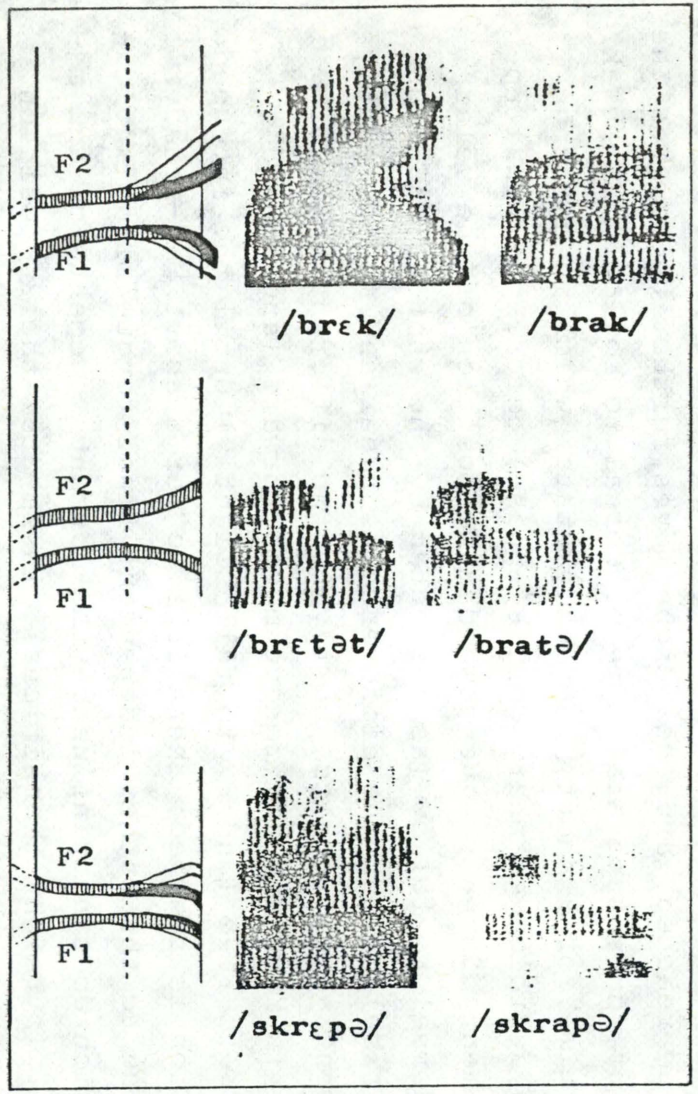

Fig. 7. SN

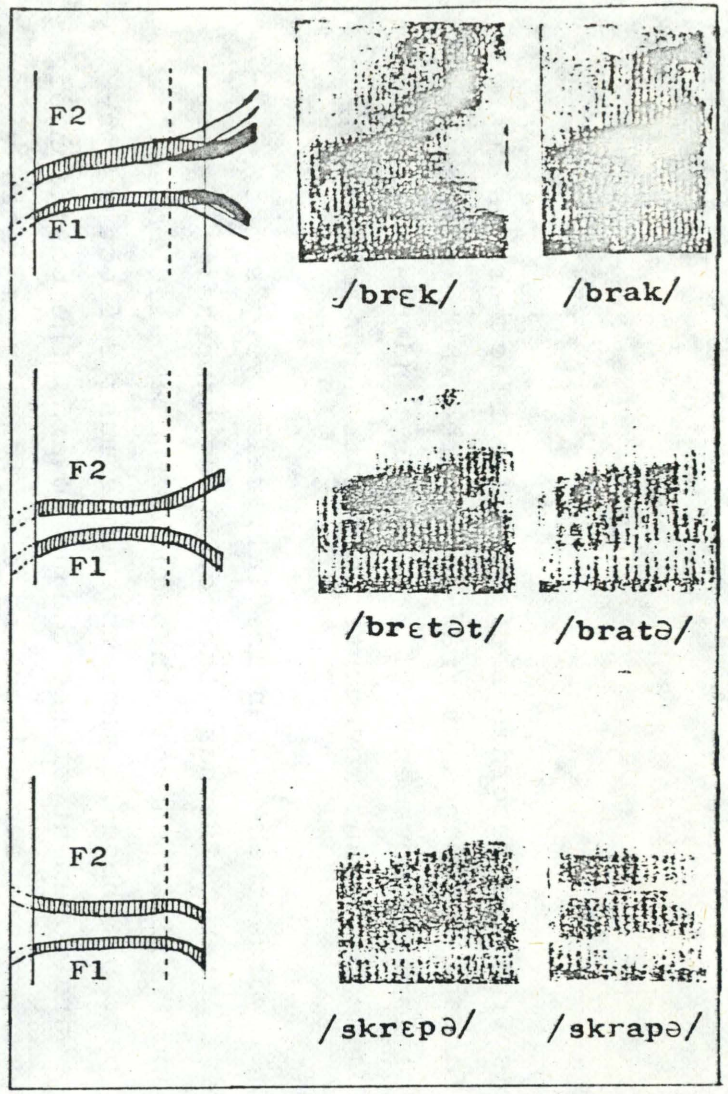

Fig. 8. BJ

Fig. 6-8. Three different stages of [ʁ]-lengthening exemplified by spectrograms of the vocalic phase of different word types and by stylized drawings of the formant movements, cf. text.

Consider next the articulatory and acoustic consequences of a moderate ʁ-lengthening, other factors being constant: The situation may now be visualized as in fig. 7. The spectrograms are from the recordings of SN who seems to represent this stage. The formants of both /rɛ/- and /ra/-words now follow the same path for a considerable stretch of time. During (roughly) the last half of the vocalic phase the following happens: If the succeding consonant is dorsal, F_2 of /rɛ/-words, still aiming at the high locus of a postpalatal, rises sharply as before. There is even less time for any [æ]-steady state to be reached, but owing to the different transitional effects of the following consonants (postpalatal vs. velar), the difference between /brɛk/ and /brak/ is maintained. If the succeding consonant is alveolar, the forward movement of the tongue towards the [æ]-position begins too late for any [æ]-steady state to be reached before the tongue blade articulation sets in, and the formant movements (in particular the F_2-rise) simply coincide with the transitions expected between [ɑ] and an alveolar, and is easily perceived as such. If the [ʁ]-lengthening is roughly the same in all types, the situation will be quite different in words with postvocalic labials: owing to the independent lip articulation the movement of the tongue towards the [æ]-position after the $ʁ^{ɑ}$-phase will not coincide with any other expected tongue movement; correspondingly, the late F_2-rise will not be perceived as the transition of a labial, since such a transition is expected to be negative and considerably shorter.

Thus merger before alveolars and no merger before labials and dorsals are the natural articulatory, acoustic, and perceptual consequences of an adequately prolonged $ʁ^{ɑ}$-phase. With an extreme [ʁ]-lengthening as shown in fig. 8 (the spectrograms are from the recordings of BJ who represents this stage), the pharyngeal phase is so long that there is only time for the transitions (needed anyway) of the postvocalic consonants, even in words with postvocalic labials in which the transitions are shortest. (In fig. 6-8 the $ʁ^{ɑ}$-phases of all types are normalized with regard to duration, and the transitions in fig. 7 and 8 are drawn longer in the words with postvocalic tongue consonants so as to give a more realistic picture of the relative durations of different phases; thus, when we speak of other factors being constant, cf. above, we of course disregard durational changes automatically implied by the [ʁ]-lengthening.) In this type of speech the impressionistic vowel quality is very [ɑ]-like in /rɛ/-words ending in alveolars and labials, cf. the apparently complete merger of these words in the speech of BJ. In /rɛ/-words with postvocalic dorsals, i.e. postpalatals, the impressionistic vowel quality is rather diphthongal. The difference between /rɛ/-words and /ra/-words ending in dorsals seems to be exclusively due to the different postvocalic consonants in this type of speech. Thus, if we assume that the changes are initiated by a pharyngealization and lengthening of [ʁ], an articulatory-acoustic model based on our investigation will predict the tendencies reported by Brink and Lund (and others), viz. the following ones: (1) a /rɛ/-/ra/-merger will primarily take place before alveolars, (2) with further [ʁ]-lengthening the merger will eventually extend its domain to incorporate the words with postvocalic labials, (3) no merger will take place before dorsals. It should be noted that our model does not imply that the speakers intend to pronounce /rɛ/- and /ra/-words in the same way. Even if the speakers intend to move the tongue towards an [æ]-position in /rɛ/-words, the acoustic and perceptual fusion will take place for purely mechanical reasons provided that the [ʁ]-lengthening is long enough. If we presuppose, for instance, that FR still intends to pronounce /skrɛpə/ and /skrapə/ differently, this explains the acoustic results mentioned in section 4 above: If the [ʁ]-lengthening of FR is assumed to have reached a stage intermediate between that of SN and that of BJ, it is to be expected that in most instances the difference is clear, whereas there is occasionally an extra-lengthening of the $ʁ^{a}$-phase which is just long enough to obscure the acoustic difference. If this is true, the situation of (at least some of) our subjects seems to be opposite to that of the English-speaking subjects who are reported by Labov (1972) to produce constant acoustic differences which they do not use to distinguish words (and are not themselves capable of perceiving). It seems probable that some of our subjects intend to distinguish words by a constant difference which, in their performance, is obscured owing to the physiological and acoustic properties of the sequences involved.

6. Concluding remarks

If our model is accepted as an explanation of the different behaviour of /rɛ/-words with different types of postvocalic consonants, the series of questions posed by the above-mentioned changes is reduced to one: Why does [ʁ]-lengthening take place? This is probably not a phonetic problem, and of course our model is not explanatory in a narrower sense. The value of a detailed acoustic study of change in progress lies in the fact that it helps to disclose the influence of inherent phonetic factors which may be obscured by traditional statements about sound change considered in terms of segments or features.

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AN INVESTIGATION OF THE FUNDAMENTAL FREQUENCY OF VOWELS AFTER VARIOUS DANISH CONSONANTS, IN PARTICULAR STOP CONSONANTS

Vivi Jeel

Abstract:

In the experiment reported, it is investigated how the fundamental frequency of the vowels starts after various Danish consonants. The main result of the experiment is that the vowel starts at a lower frequency after Danish bdg than after ptk.

1. Introduction

Investigations of languages with voiced bdg and voiceless ptk have shown that the fundamental frequency of the following vowel is lower after bdg than after ptk.

House and Fairbanks (1953) investigated the fundamental frequency of American vowels preceded and followed by the same consonant. They found that the average fundamental frequency of the vowels was decreasing, according to the surrounding consonants, in the order ptk > fs > bdg > vzmn. The mean difference between vowels, preceded and followed by bdg and ptk, was 6 Hz. However, they did not know whether it was the preceding or the following consonant that exerted the greatest influence on the vowels. Data from ten male subjects formed the material investigated.

Lehiste and Peterson (1961) investigated the fundamental frequency of American vowels in various consonant surroundings. They measured the maximum fundamental frequency and found that a preceding consonant influences the average fundamental frequency of the following vowel, which is decreasing in the order ptk > fsh bdgl > mn > v. The average difference between the fundamental frequency of vowels after bdg and ptk was 12 Hz. The following consonant had no influence on the vowel. Only one American male subject was used in this investigation.

Kim (1965) found that in Korean, vowels following the weakly aspirated voiceless stops start a little lower than vowels following the unaspirated voiceless and the strongly aspirated voiceless stops. The weakly aspirated voiceless stops of Korean are lenes, whereas the other two categories are fortes.

Slis and Cohen (1969) investigated the fundamental frequency of Dutch vowels after voiced and voiceless consonants. They found that vowels after voiced consonants have a maximum which, on an average, is 6 Hz lower than that of vowels after voiceless consonants.

Fischer-Jørgensen (1972) investigated French stop consonants between vowels. The fundamental frequency of the following vowel was measured for one of the subjects. The vowel started on a lower frequency after bdg than after ptk in 75 out of 78 pairs. The average difference was 27 Hz.

In his investigation of Swedish tonal accents Öhman found that the fundamental frequency initially in the stressed vowel was highest after the voiceless stop k, lowest after the voiced consonants g, j, and v, and intermediate after the voiceless fricatives f and c.

Haycock and Haggard (1970) found that vowels start on a higher fundamental frequency after ptk than after bdg. The difference was 5-6 Hz.

In an experiment with synthetic syllables Haggard et al. (1970) made the following observation: if a syllable is ambiguously perceived as beginning with p or b when the following vowel has level pitch, then a change of the pitch so that it starts at a higher frequency suffices to make the subjects perceive the consonant as voiceless. If, on the contrary, the starting-point is lowered (in relation to the originally level pitch), the consonant is heard as voiced. 12 English subjects took part in the perceptual test.

Fujimura (1971) carried out an experiment with synthetic syllables and found that the frequency at the start of the following vowel is important for the perception of the stop consonants as voiced or voiceless. 10 American and 3 Japanese subjects were asked to judge a synthetic syllable with various voice onset times as either [kε] or [gε]. The shift from g to k occurred at a somewhat longer voice onset time for the American subjects when the starting fundamental frequency of the vowel was low and rising from 70 to 100 Hz, than when the vowel started at 100 Hz and exhibited no rise. One of the Japanese subjects was totally reluctant to change the answer from g to k when the fundamental frequency of the vowel started at a low level.

Halle and Stevens (1971) want to explain the connection between type of consonant and vowel pitch in terms of common features. They argue that - according to studies of the mechanism of vocal cord vibrations - the factors conditioning higher versus lower fundamental frequency include stiffening and slackening of the vocal cords. Halle and Stevens give voiceless ptk the features [-slack vocal cords, +stiff vocal cords] and voiced bdg the features [+slack vocal cords, -stiff vocal cords]. Danish voiceless ptk will get the features [-slack vocal cords, +stiff vocal cords] and Danish voiceless bdg the features[-slack vocal cords, -stiff vocal cords].

2. The present investigation

All investigations mentioned above, except the one on Korean, concern languages with voiced bdg and voiceless ptk. In the experiment reported in the present paper it was investigated how the fundamental frequency of the vowel starts after Danish stop consonants. These stops are all voiceless, the main difference between ptk and bdg being one of aspiration.

2.1. Material

The material consisted of the following words: *pane [p^{h}a:nə], bane [ba:nə], pande [p^{h}anə], bande [banə], tale [t^{h}a:lə], dale [da:lə], tande [t^{h}anə], danne [danə], kane [k^{h}a:nə], gane [ga:nə], kande [k^{h}anə], and *ganne [ganə]. Moreover, the following words were included for comparison: fane [fa:nə], *fanne [fanə], *sane [sa:nə], sande [sanə], hale [ha:lə], Hanne [hanə], mane [ma:nə], malle [malə], *nale [na:lə], nalle [nalə], vane [va:nə], valle [valə], *lane [la:nə], and lande [lanə].[1] All the test words were said in the carrier sentence (sig ordet - igen: 'say the word - again'). The tested consonants are all in initial stressed position.

2.2. Subjects and recording

The sentences were read in random order by 3 female subjects: EC, EH, and VJ and 3 male subjects: LG, JJ, and BM. All the subjects are students of phonetics and speak Standard Danish. They all have strongly aspirated <u>ptk</u> and furthermore strongly affricated <u>t</u>, and all have a low pitch on the stressed syllables gliding to a higher tone in the unstressed syllables. 4 of the subjects: EC, EH, JJ, and VJ read the whole material. BM read the sentences with stop consonants and with <u>fs</u>. LG only read the sentences with stop consonants. All the subjects read the material 6 times each. Thus the material consists of 792 words, of which 432 have a stop consonant initially. The recordings took place in the studio of the Institute of Phonetics. A professional Lyrec tape-recorder was used. The speed of the tape was 7½"/sec.

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1) Words marked by means of an asterisk are possible but nonexistent Danish words.

2.3. Registration

The signal from the tape recorder (the same as used for recording) passed a pitch-meter and an intensity meter. By means of a mingograph 4 curves were obtained:

a. a duplex oscillogram.
b. a logarithmic intensity curve, high-pass filtered at 500 Hz and with an integration time of 2.5 msec.
c. a linear, unfiltered intensity curve with an integration time of 10 msec.
d. a pitch curve.

2.4. Measurements

The fundamental frequency was measured in Hz at 7 points in each sentence. Fig. 1 shows where these points were measured on the pitch curve. The measured points are:

1. the minimum at the end of the carrier phrase ('ordet').
2. the start of the initial consonant in the test word.
3. the minimum of the initial consonant.
4. the start of the voiced aspiration (only p and k).
5. the start of the stressed vowel in the test word.
6. the minimum of the stressed vowel.
7. the end of the stressed vowel.

Moreover, the distance from the start of the stressed vowel to the minimum of the fundamental frequency in that vowel was measured.

The results of the measurements for each subject are separated in the comparison. The female voices are measured with an accuracy of about 5 Hz and the male voices with an accuracy of about 2 Hz. No difference can be found between the start of the long and the short vowels, nor between the minima of these vowels.

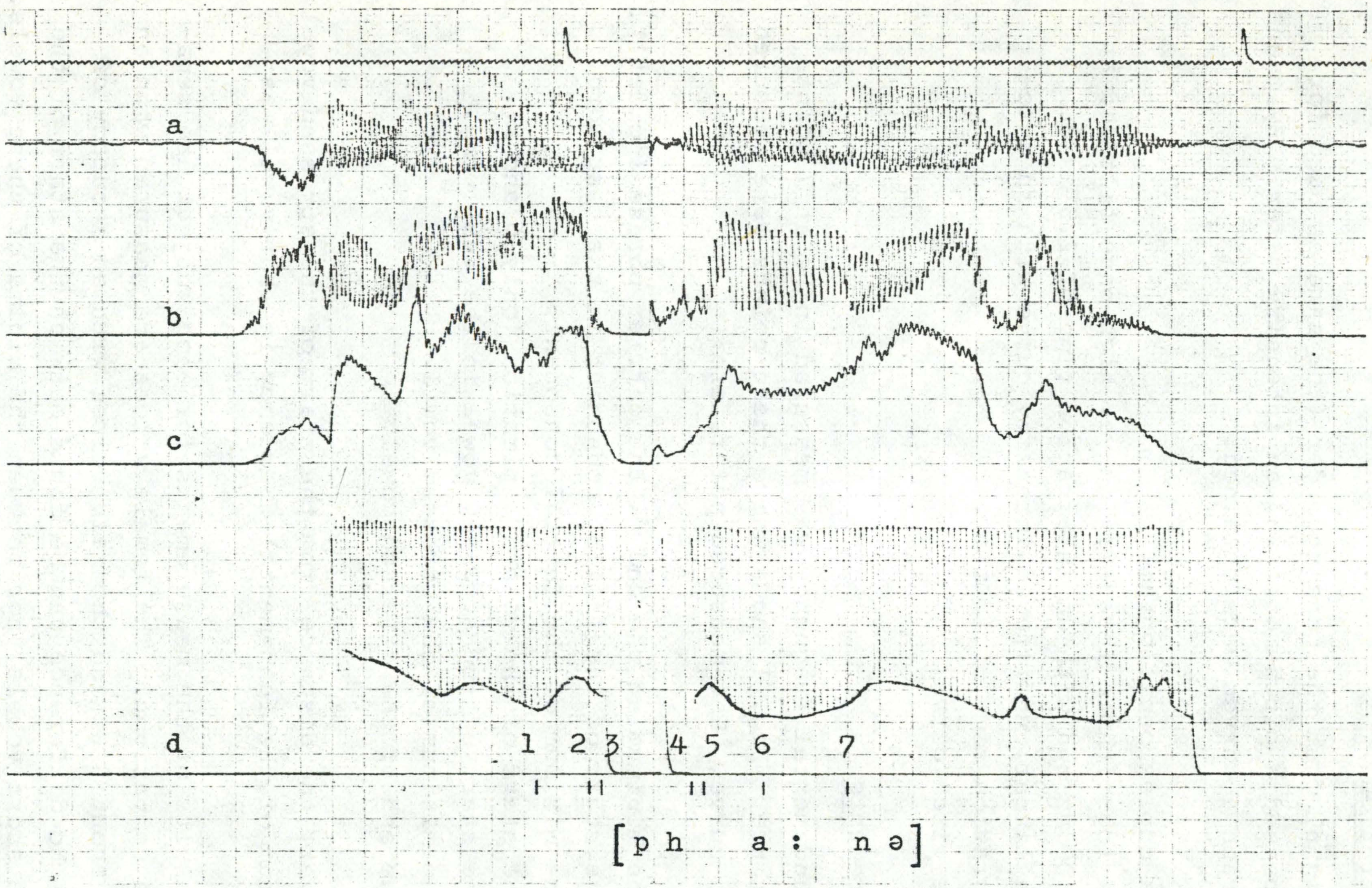

Figure 1

Mingogram of [pʰa:nə]. Subject LG.
The numbers refer to the measured points on the pitch curve.

For that reason, the long and the short vowels are not separated, except for the frequency at the end of the vowel, which exhibits a significantly higher value in long vowels than in short vowels. A t-test was used to investigate at which level of significance (99.9, 99, or 95%) the difference between word-pairs such as 'pane - bane' could be said to differ from zero. Some of the consonants have been combined, so that there are 7 groups in all: ptk, bdg, fs, h, mn, v, and l. The first and second group each comprises 36 examples, the third and fifth group 24 examples, and the fourth, sixth and seventh group 12 examples for each subject. Two of the subjects: EC and EH have fully voiced h, JJ has voiceless h, and VJ has partly voiced or voiceless h.

3. Results of the measurements

3.1. Fundamental frequency of the minimum at the end of the carrier phrase

No difference was found.

3.2. Fundamental frequency at the start of the initial consonant of the test word

None of the subjects has any difference between the start of ptk and bdg. BM has no difference between the start of stop consonants and fs. EC has decreasing frequency at the start of the consonants in the order ptkbdgfs > h > mnvl. For EH the order is ptkbdg > fs > h > mn > l > v, for JJ ptkbdg > mn > fshvl, and for VJ ptkbdg > smnl > hf > v.

3.3. Fundamental frequency at the minimum of the initial consonant in the test word

The voiceless consonants are often slightly voiced at the beginning. The minimum was measured where the voiced oscillations stop, but as these oscillations are of different duration, the value of this measure is dubious. Besides, in nasals the pitch curve falls from the beginning of the consonant to the start of the following vowel. A comparison of the minima is therefore meaningless.

3.4. Fundamental frequency at the start of the voiced aspiration

The last part of the aspiration is voiced after most p's and some k's. The voiced aspiration can be separated from the vowel by means of the weak intensity of the oscillations which is followed by a rather sudden increase of intensity coinciding with a change of the direction of the pitch curve from rising to falling. The spectral energy of these weak oscillations is concentrated at a very low frequency. JJ has no voiced aspiration. In the case of the other subjects (except VJ), the voiced aspiration starts at a clearly higher frequency than the vowel after bdg. VJ has no difference between the start of a voiced aspiration and the start of the vowel after bdg.

3.5. Fundamental frequency at the start of the stressed vowel in the test word

All the subjects have a lower start of the vowel after bdg than after ptk. Three of the four subjects who read the test words containing voiced consonants (m, n, l, v), have a lower start of the vowel after voiced than after voiceless consonants (except JJ who has hardly any difference). Figs 2-7 contain histograms of the fundamental frequency at the start of the vowel

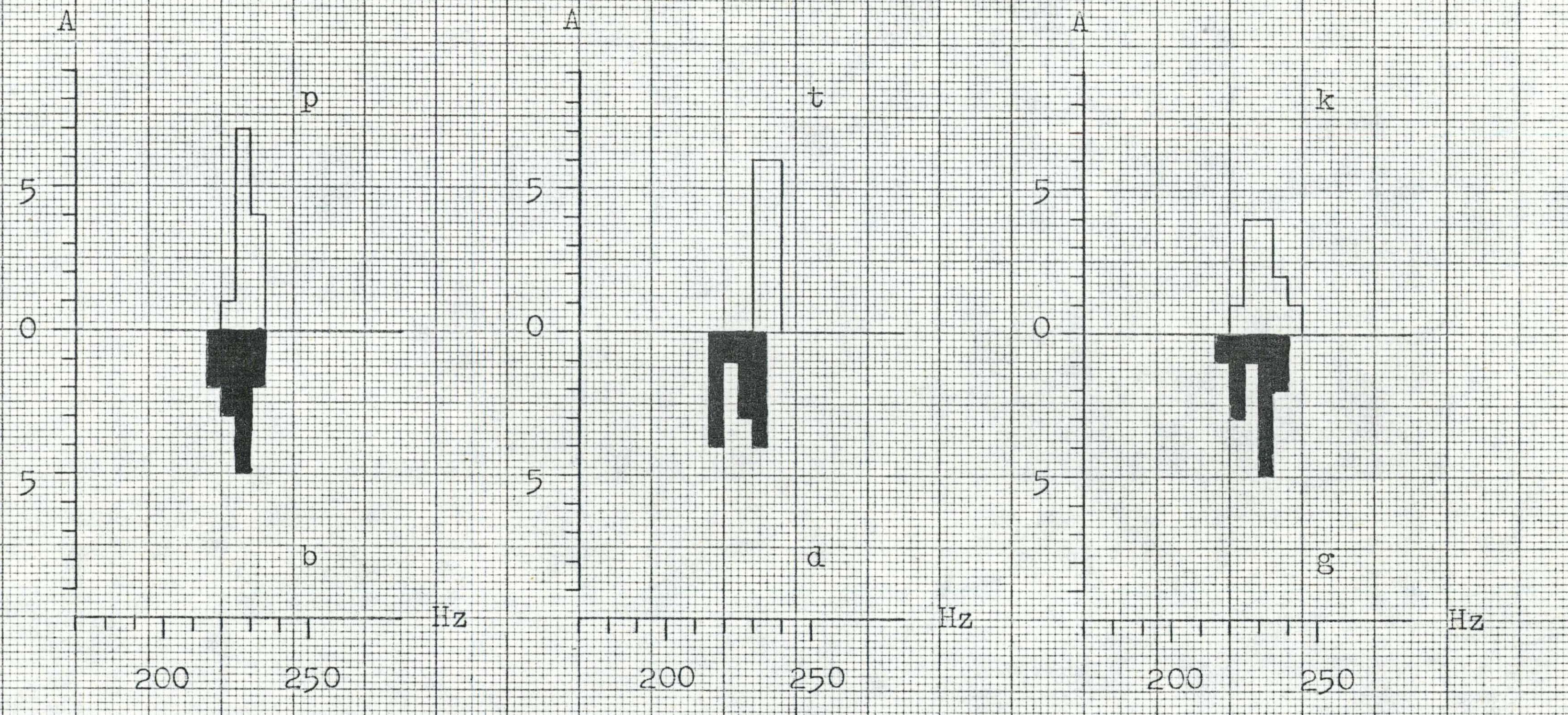

Figure 2. Fundamental frequency at the start of the vowel after <u>ptk</u> and <u>bdg</u>. (Subject VJ).

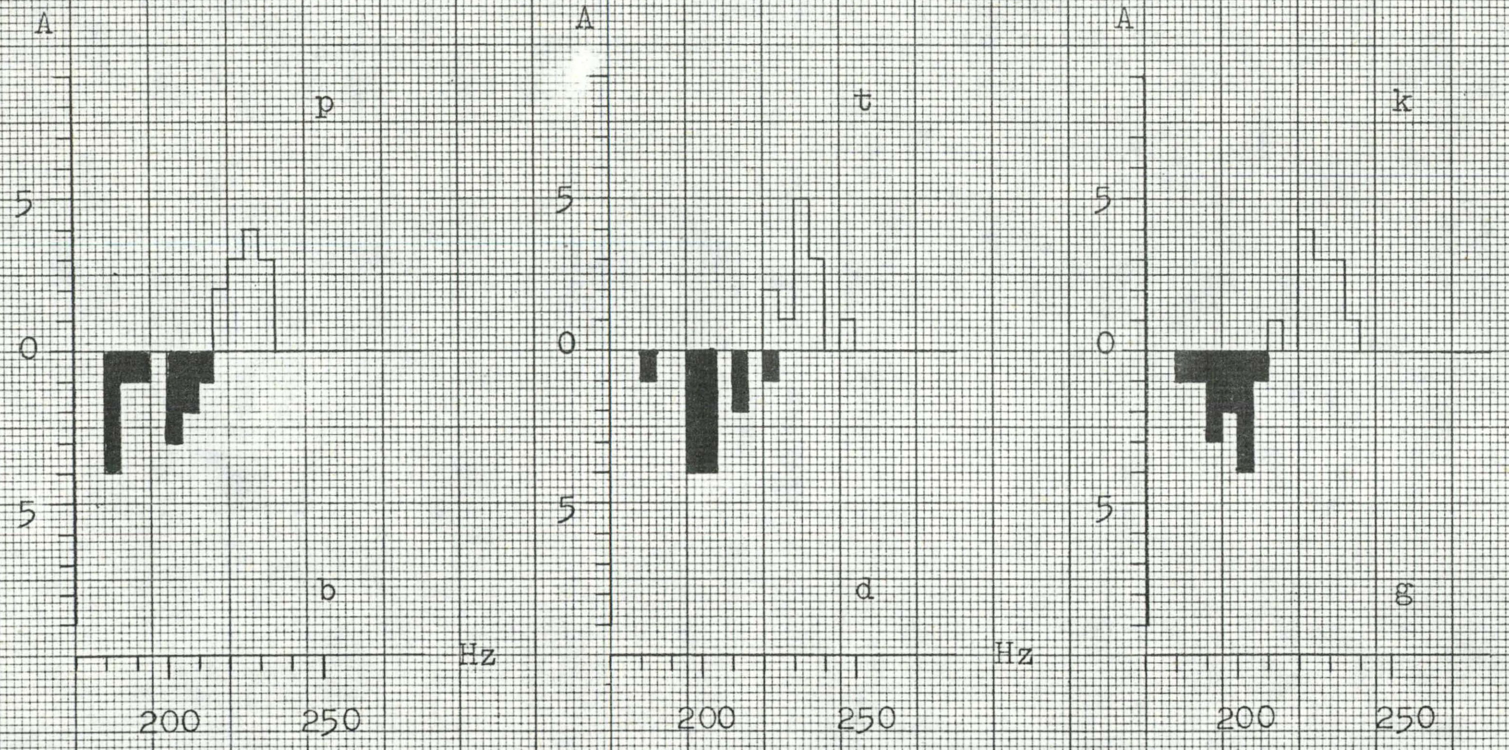

Figure 3. Fundamental frequency at the start of the vowel after ptk and bdg. (Subject EC).

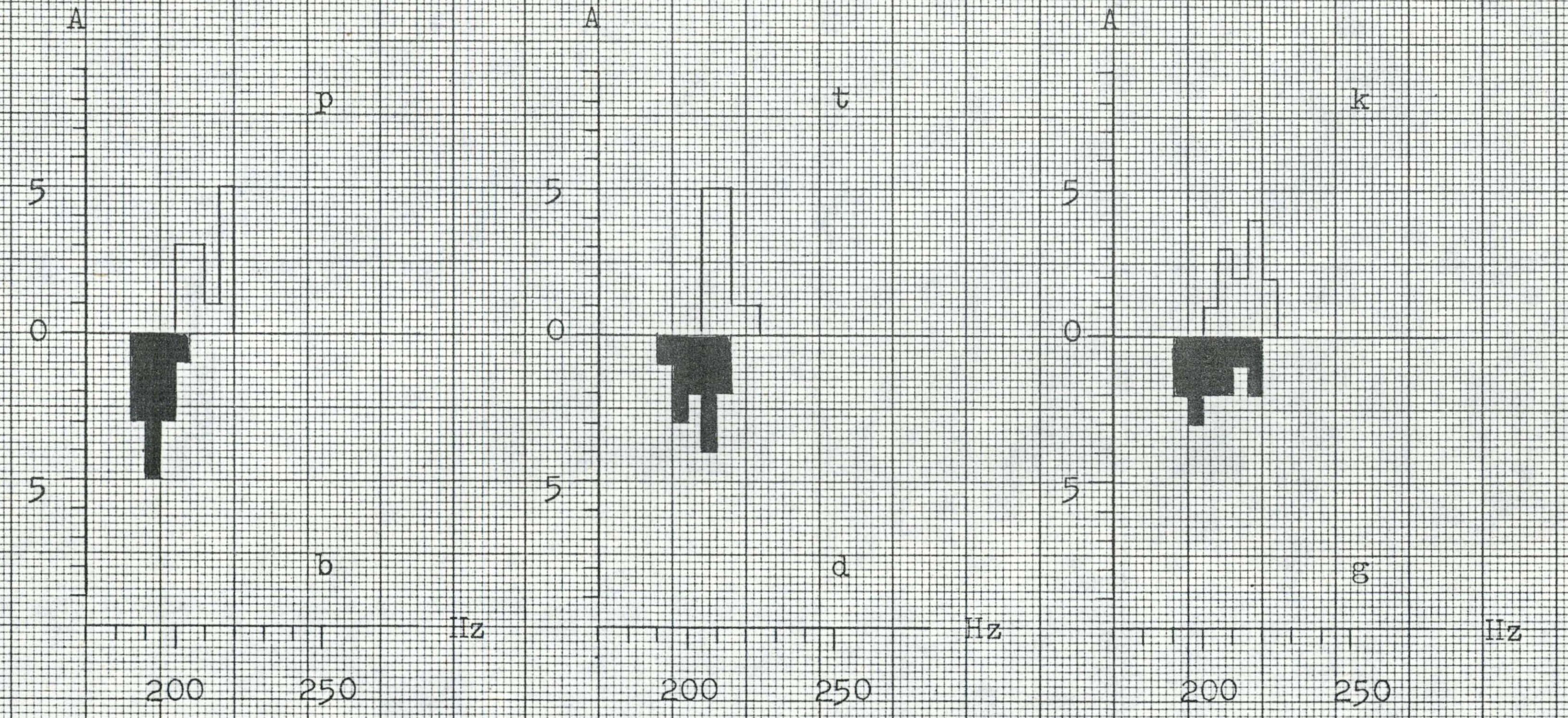

Figure 4. Fundamental frequency at the start of the vowel after ptk and bdg. (Subject EH).

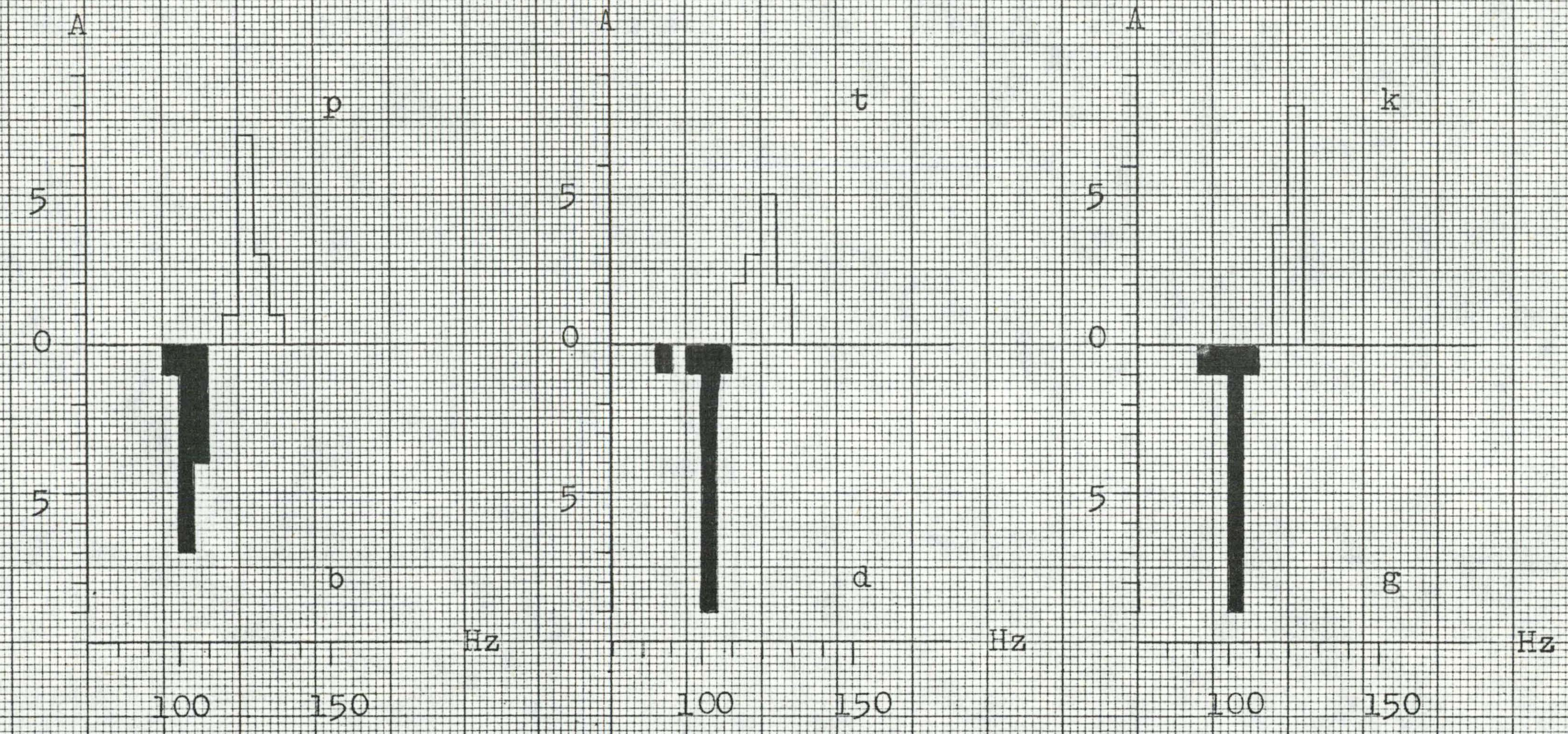

Figure 5. Fundamental frequency at the start of the vowel after <u>ptk</u> and <u>bdg</u>. (Subject LG).

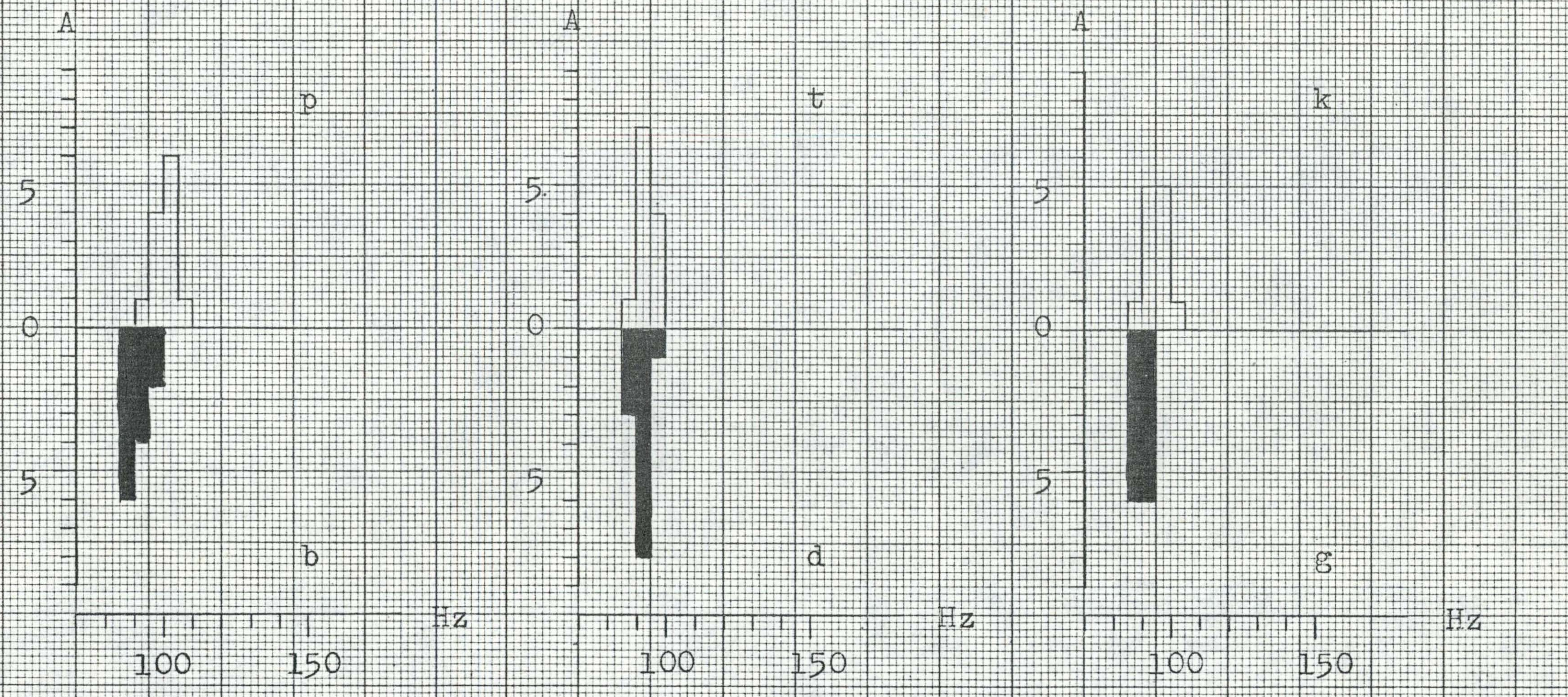

Figure 6. Fundamental frequency at the start of the vowel after <u>ptk</u> and <u>bdg</u>. (Subject BM).

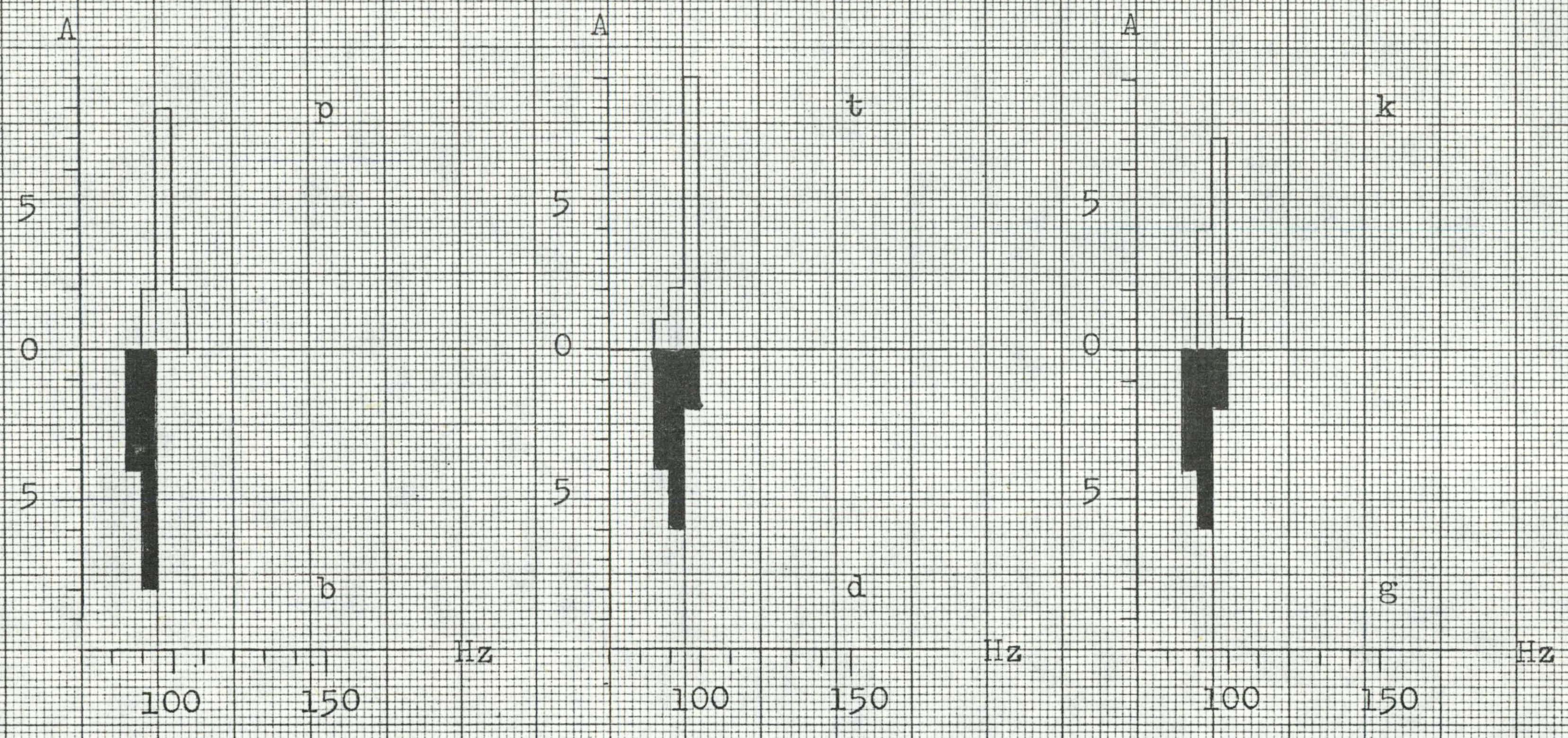

Figure 7. Fundamental frequency at the start of the vowel after ptk and bdg. (Subject JJ).

after the different stop consonants, and figs 8 and 9 show the mean fundamental frequency at the start of the vowel after all the consonants. The differences between the average fundamental frequencies at the start of the vowel can be seen in table I, and table II shows whether these differences are significant, and on which level.

3.6. Fundamental frequency of the minima in the stressed vowel

The differences between the minima in the vowels following different consonants are less pronounced than the differences between the start of the vowels. For none of the subjects are the differences significant.

3.7. Fundamental frequency at the end of the stressed vowel

The long vowels end on a higher F_o than the short vowels for all subjects. The difference in fundamental frequency between different consonant types is nearly equalized at the end of both the long and the short vowels. There is, however, a tendency for all subjects to retain a small difference, so that the fundamental frequency of both the long and the short vowels is decreasing according to the preceding consonants in the order ptkh > bdgfs > mnvl.

3.8. Distance from the start of the stressed vowel to the frequency minimum in the vowel

The measurement of the distance from the start of the vowel to the minimum in the vowel is a problematic matter, because the mid part of the vowel has a rather flat F_o curve and it is difficult to decide where the minimum is. But the tendency is that the minimum is reached later in the long vowels than in the short

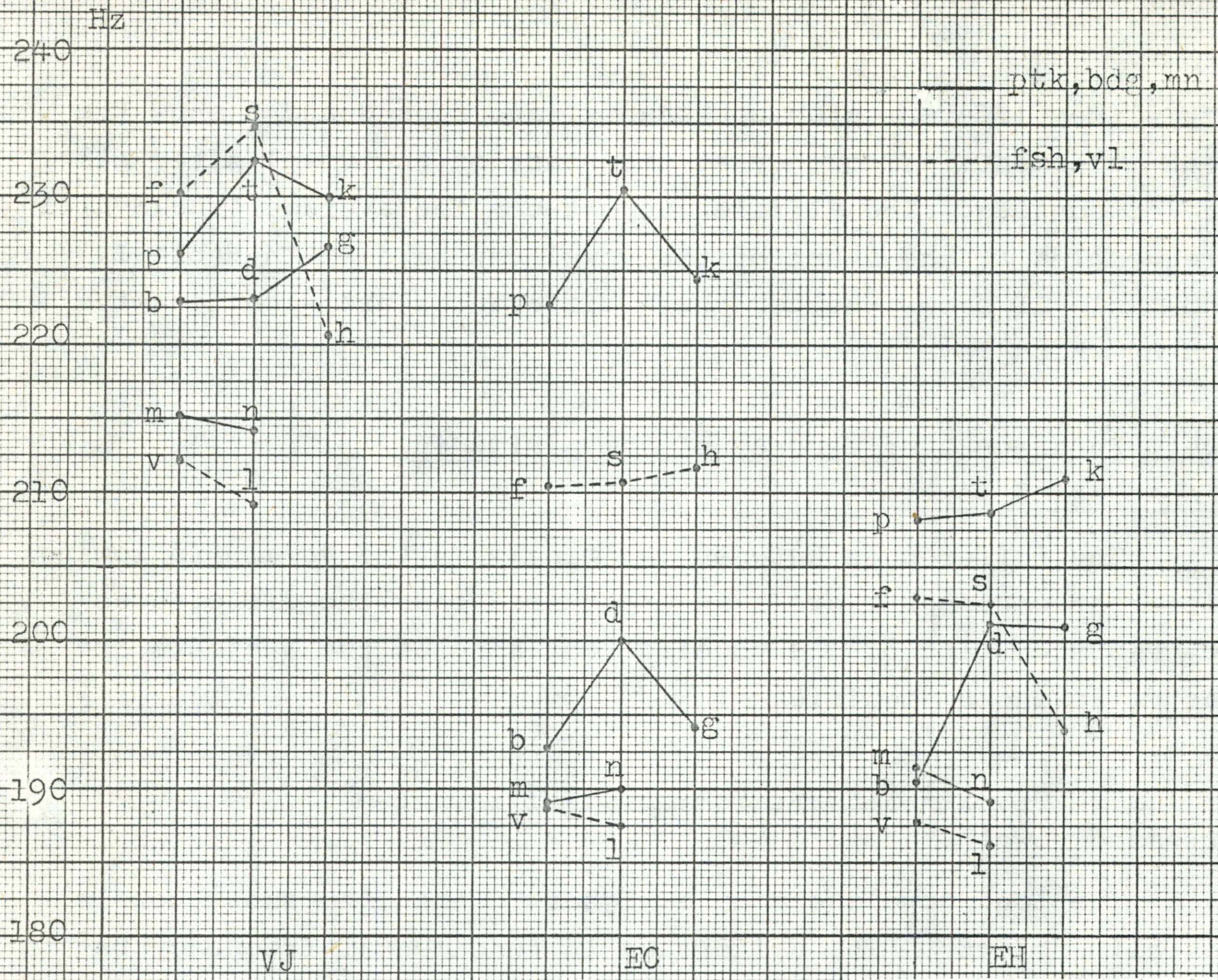

Figure 8. Fundamental frequency at the start of the vowel after various consonants. Female subjects.

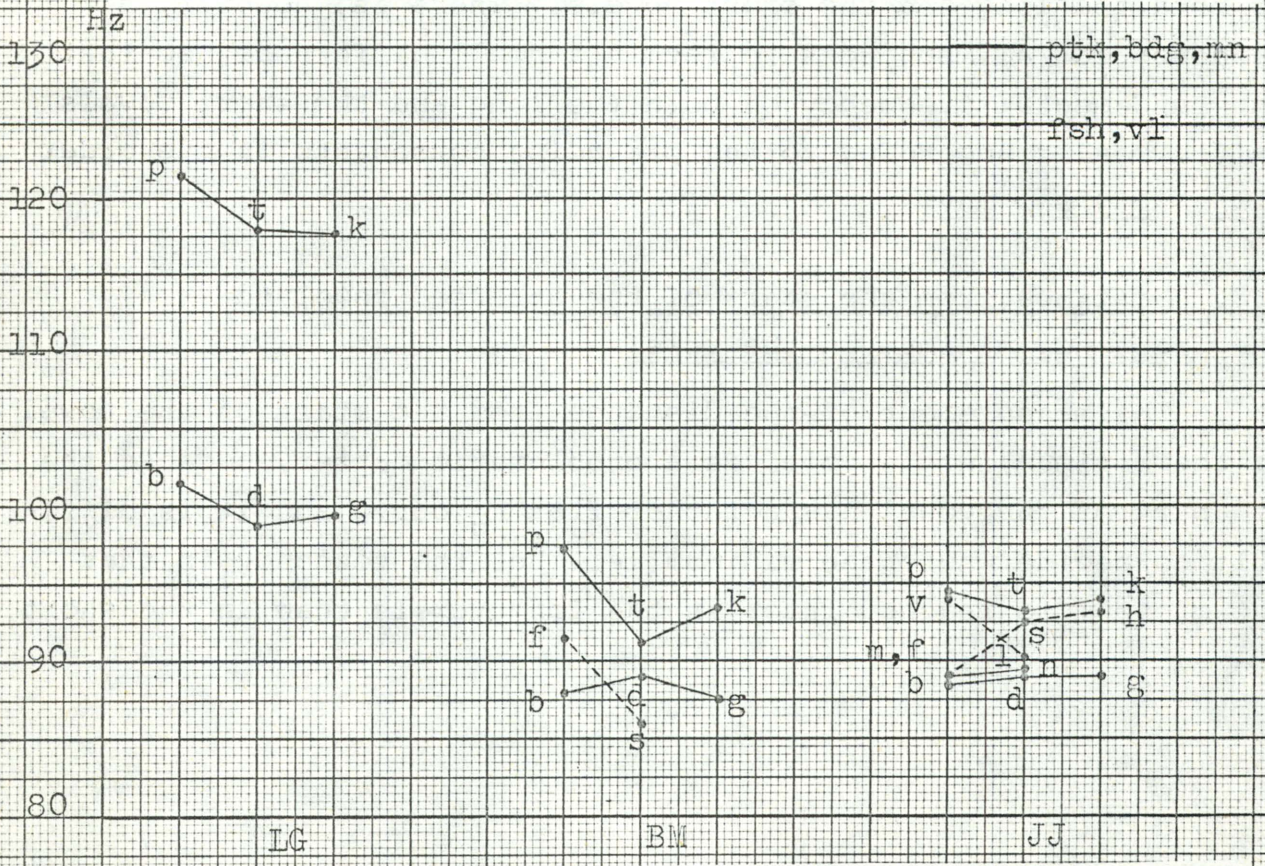

Figure 9. Fundamental frequency at the start of the vowel after various consonants. Male subjects.

TABLE I

Differences between the average frequency values (in Hz) at the start of vowels after various consonants

	VJ	EC	EH	LG	BM	JJ
p	226.3	222.8	208.2	121.5	97.2	94.6
b	223.1	192.8	190.5	101.5	88.1	88.5
diff.	3.2	30.0	17.7	20.0	9.1	6.1
t	232.5	230.6	208.9	118.0	91.0	93.3
d	223.2	200.0	201.4	98.7	89.1	88.9
diff.	9.3	30.6	7.5	19.3	1.9	4.4
k	229.9	224.4	211.1	117.7	93.4	94.1
g	226.8	194.2	201.1	99.4	87.4	89.0
diff.	3.1	30.2	10.0	18.3	6.0	5.1
p	226.3	222.8	208.2		97.2	94.6
f	230.2	210.5	202.9		91.4	88.8
diff.	-3.9	12.3	5.3		5.8	5.8
t	232.5	230.6	208.9		91.0	93.3
s	234.7	210.8	202.4		86.1	92.4
diff.	-2.2	19.8	6.5		4.9	0.9
k	229.9	224.4	211.1			94.1
h	220.8	211.8	194.0			93.2
diff.	9.1	12.6	17.1			0.9
b	223.1	192.8	190.5			88.5
m	215.2	189.2	191.6			89.0
diff.	7.9	3.6	-1.1			-0.5
d	223.2	200.0	201.4			88.9
n	214.2	190.0	189.2			89.5
diff.	9.0	10.0	12.2			-0.6
b	223.1	192.8	190.5			88.5
v	212.2	188.8	187.7			94.2
diff.	10.9	4.0	2.8			-5.7
d	223.2	200.0	201.4			88.9
l	209.2	187.5	186.3			90.3
diff.	14.0	12.5	15.1			-1.4

TABLE II

The table shows whether the difference between averages of the frequency at the start of vowels after various consonants is significant and on which level

	VJ	EC	EH	LG	BM	JJ	
ptk	+ >	+++ >	+++ >	+++ >	+ >	+ >	bdg
pt	<	+++ >	>		++ >	>	fs
k	+++ >	+++ >	+++ >			>	h
bd	+++ >	>	>			<	mn
b	+++ >	>	>			<	v
d	+++ >	+++ >	+++ >			<	l

> means that the fundamental frequency at the start of the vowel is higher after the consonants listed in the left-hand column than after those listed in the right-hand column; < means that it is lower. + indicates the 95% significance level, ++ 99%, and +++ 99.9%.

vowels. Besides, there is a tendency that the distance to the minimum is decreasing according to the preceding consonants in the order ptkh > bdgfs > mnvl, but there are individual deviations from this tendency.

4. Conclusion

The difference between the fundamental frequencies of vowels after bdg and ptk is often explained as a distinction between voiced and voiceless consonants, and the investigation reported here does show that the vowel tends to start at a low frequency after the voiced consonants, viz. m, n, l, v. But there is also a difference between the fundamental frequencies of vowels after Danish bdg and ptk. This cannot be explained as a voiced-voiceless distinction, since both Danish bdg and ptk are voiceless. - According to Halle-Stevens [ptk] should have stiffer vocal cords than [bdg]. This issue cannot be settled on the basis of the present investigation.

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CONGRESS PAPERS AND SUMMARIES OF MONOGRAPHS

PERSPECTIVES IN PHONOLOGY[1]

Eli Fischer-Jørgensen

It was only after a good deal of hesitation that I accepted the invitation of the committee to speak about phonology in a plenary session of this congress. I have never made any significant contribution to phonological theory, nor have I tried to apply it to any concrete language. It is true that I have just written a book on phonology, but that was, so to speak, unintentionally; it somehow grew out of my teaching (what I really wanted to do was experimental phonetics). - As for phonology, I have been an interested, now and then somewhat baffled, spectator of the development. But perhaps, what the committee looked for was a relatively unbiased spectator.

Let me add that I have been lucky to be able to draw heavily on the expertise of my colleagues Jørgen Rischel and Hans Basbøll, whose stimulating criticism has been extremely valuable and has led to significant improvements in the present paper.

When you look back at the development of phonology it seems to have followed a rather tortuous path, or rather various paths. The phonologists may be compared to a somewhat disintegrated group of mountain climbers, aiming more or less at the same peak (or group of peaks) which - when viewed from the valley - seemed within quite easy reach, but which went out of sight as soon as they started climbing. Sometimes, what looked like the best track went horizontally for a long while, farther and farther away from the last resting-place, and some found that the start had been quite wrong and should have taken place from a wholly different angle. Sometimes the track disappeared completely,

1) Paper read at the 8th international congress of phonetic sciences in Leeds, 1975 (plenary session)

and various climbers insisted on using detailed maps and planning each step carefully. The maps, however, did not seem to be sufficiently exact, and some years ago some climbers rejected the use of maps altogether and found it safer to use their intuition and hope for the best. Although they got many adherents, there are still some who would like to know where they are. And I think a congress is a good occasion for just taking breath for a moment and asking ourselves where we are, what we are aiming at, and how we can hope to reach - or at least approach - that aim.

I. The first question - where are we now? - can be slightly reformulated to mean: What have been the most conspicuous developments in phonological theory since the last congress?

It should first be stated that in the course of these years generative phonology has been adopted, or at least studied and discussed, by an increasing number of young linguists all over the world. It is now taught in a great number of universities, and there may even be young students who do not know that other respectable trends of phonology have existed and still do exist. Such a general spread of a linguistic theory has hardly been seen since the days of the Neo-grammarians. During the intervening structuralist period there was a locally determined split-up into rather deviant schools.

There are various reasons for the success of generative phonology. Better communication has been a condition, but it is, of course, by no means a sufficient explanation. What has been very important is, I think, the fact that transformational grammar, including generative phonology, has broken the isolation of linguistics resulting from the endeavour of structuralism to make linguistics an autonomous science, a laudable endeavour at that time, but in the long run detrimental to a fruitful development. Transformational grammar opened up wider perspectives by emphasizing the relations to psychology and the importance of studying universals and by claiming that linguistics should not only provide descriptions, but also explanations, perspectives which had been almost cut off in American structuralism. But it should not be forgotten that the interest in universals and in explanation was vivid in European structuralism, particularly in the Prague School, and that generative phonology owes much to Roman Jakobson in these respects. - The endeavour to set up models and to formulate explicit rules also contributed to the success. It should, however, be remembered that the formulas used, for instance, in "Sound Patterns of English" are simple abbreviations of normal prose. They may be a practical means to avoid ambiguity and to make sure that nothing has been left out, but they do not constitute a sort of mathematics. - Some linguists, searching for a means to get rid of the non-uniqueness of structural descriptions, may also have been impressed by the assertion of the first adherents of transformational grammar, that they had found the only correct solution, the one corresponding to the tacit knowledge of the speaker-hearer. This assertion, however, is not only one of the most interesting but also the most dubious of all the assertions of generative phonologists, and the incredible self-assurance with which it was propounded (again, by the way, reminiscent of the Neo-grammarians) also had the effect of keeping a good many, more level-headed linguists aloof from the new ideas.

Along with the diffusion of generative phonology, however, a remarkable relaxation of the orthodoxy has taken place. Important modifications of the theory have been proposed, both by professed adherents, for instance by Kiparsky (in a series of excellent papers), by Schane, McCawley and Stephen Anderson, and also by linguists who are, in the main, in sympathy with the endeavours of generative phonology but do not consider this the only possible way of describing language (like Rischel and Basbøll)[1].

The high degree of abstractness of underlying forms in early generative phonology was criticized by Kiparsky as early as 1968 (1968a). He proposed in particular two modifications: (1) underlying forms differing in phonological specification from surface forms should only be set up in the case of alternations, and (2) they should not contain segments which are never realized on the surface (the so-called "absolute neutralization"). This excludes, for instance, œ or x in English. Various phonologists have joined in this criticism (e.g. Shibatani 1971, Vennemann 1972a, Wang 1973); others (e.g. Brame 1972 and Hyman 1970) have maintained that the simplicity obtained by using such abstract underlying segments is legitimate in language description. In some later articles (1971, 1972), Kiparsky discussed the matter again and proposed that absolute neutralization should be allowed in cases where the underlying contrast is crucial to more than one rule of the language.

Restrictions on language specific (extrinsic) rule ordering were proposed by Chafe (1967). Stephen Anderson (1974) goes further and attacks the general notion that rules are, on the whole, linearly ordered. He assumes that only pairs of rules, not whole sets of rules, are mutually ordered and only with respect to a given form. In accordance with Kiparsky (1968b), he suggests that rules tend to apply in a universally determined order, the two most important principles being maximum effect of the rules and transparency of the result. In a later paper (1971), Kiparsky gives preference to the latter principle. Complete abolition of extrinsic rule ordering has been required by Koutsoudas, Sanders and Noll in 1974.

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1) The reference list at the end of the paper contains a choice of what I have considered the more interesting contributions to phonology since the last congress, together with a few older papers. It includes also some surveys where further references may be found.

As for the distinctive features, various revisions have been proposed by Halle and Stevens, and particularly by Ladefoged, but as this topic has been treated in other sessions, I shall not enter into it here. I should only like to emphasize that I find it necessary to distinguish more sharply between the universal set of phonetic dimensions and the features of concrete languages, which generally do not consist in a simple choice of the general dimensions, but in various combinations of these general dimensions, and whose phonetic definitions will therefore vary from language to language.

More severe is the criticism which has been raised against the very basis of generative phonology, the claim that the description has psychological reality. It is true that some transformationalists, for instance Ruwet, do not make this claim and seem to consider generative phonology primarily as an efficient descriptive technique. But for most adherents this is a crucial point, because it is just this psychological basis which should justify the claim that the transformational description is superior to all previous descriptions.

This was expressed quite clearly by Chomsky and Halle in 1965: "Without reference to this tacit knowledge there is no such subject as descriptive linguistics. There is nothing to be right or wrong about". This cannot simply mean that the linguistic description should be able to generate the same sentences or forms as those generated by the speaker, for this could be done in different ways, and this is what almost all linguistic trends have aimed at. It must mean that both the underlying forms and the rules belong to what is called the internalized grammar of the speaker. They also use - on purpose - the term 'grammar' ambiguously, both of the description of the linguist and the competence of the speaker, which means that they claim a close correlation between the two.

The criticism raised by adherents of the theory against very abstract underlying forms is also, among other things, based on the argument that they can harly be part of the speaker's competence. There has been a tendency to assume that the normal speaker has the same knowledge as the linguist about etymology, although few will go so far as Lightner, proposing common underlying forms for the words ten and decimal in English.

What is astonishing now is that Chomsky and Halle do not attempt to test this claim empirically, but instead set up a purely formal evaluation measure. The formal machinery must be able to account for "linguistically significant generalizations". But the decision as to what are significant generalizations is based on a purely hypothetical assumption concerning the way in which a child acquires language. It is assumed that he has an innate knowledge of possible structures and that he will always operate with maximally general and natural rules.

The purely hypothetical character of these assumptions has been demonstrated very convincingly in some highly interesting recent monographs by Botha (1971), Derwing (1973) and Linell (1974). Linell concentrates his criticism on the problem of the psychological reality of underlying abstract morphemes and sets up an alternative analysis based on the assumption that speakers have only stored concrete wordforms and relations between these concrete wordforms. Derwing also criticizes the postulated psychological reality of underlying forms, but his criticism is particularly concentrated on the postulates of generative phonology concerning language acquisition. As early as 1968, McCawley characterized the,admittedly counter-factual, assumption of instantaneous language acquisition set up by Chomsky and Halle for reasons of simplicity, as too unrealistic. What really happens must be a constant restructuring. Both Derwing and Linell emphasize that at the start the child must store concrete wordforms, and they cannot find any proof for the assumption that at a certain stage the strategy is changed to the storage of abstract underlying forms. Derwing also demonstrates that there is no support for the contention that language acquisition presupposes a highly structured specific set of innate linguistic universals. A general capacity for generalization and structuring and for using symbols must be a sufficient hypothesis. If children cannot be supposed to be able to learn transformational grammar without the specific innate universals, it may be transformational grammar which is wrong.

Derwing's book also contains a penetrating criticism of Chomsky's varying use of the terms competence and performance, and his highly relevant criticism of generative phonology is, on the whole, based on general considerations of scientific methodology.

It is thus a characteristic feature of the present situation that most of the basic assumptions of generative phonology have been the object of serious and convincing criticism, and that many points are being revised also by the professed adherents of the theory.

This revision also includes a changed attitude to structural linguistics. Structural descriptions are no longer characterized as absurd or senseless; on the contrary: many concepts of structural phonology have been taken up again and their introduction into generative phonology reconsidered. The necessity of describing surface structure (phonotactics), for instance in order to understand the treatment of loanwords and phonological change, has been emphasized by various authors (e.g. Kisseberth 1970, Shibatani 1971, Kiparsky 1971 and 1972, and Rischel 1974). The syllable was reintroduced by McCawley (1968), and its importance for phonological rules demonstrated by Vennemann (1972b), Hooper (1972), and Basbøll (1972 and 1974). The importance of surface contrast was stressed by Schane (1971) and Wang (1973). Some have even admitted that perhaps the first transformationalists had been too rash in throwing out the phoneme with the taxonomic bathwater (for instance Schane 1971). The possible role of phoneme systems in language change is also being reconsidered (for instance by Vennemann 1972a and Kiparsky 1972). On the whole, many structural concepts are becoming respectable again. I think that this growing tolerance is very promising for future research.

A criticism which has been raised against both orthodox generative phonology and some trends of structural linguistics is the extremely formal approach which involves a neglect of physiological and acoustic phonetics and the contributions these disciplines may give to the explanation of phonological facts. This criticism has been raised particularly by John Ohala (1971, 1972c and 1974b), M. Chen (1971), and B. Lindblom. I think above all of Lindblom's very important paper at the last congress in 1971, which will be continued at this congress tomorrow.

Let me finally mention that the sociological aspect of language has until now been neglected in all trends of phonology, and quite particularly in generative phonology. The importance of this aspect for the explanation of phonological change appears very clearly from the works of W. Labov (e.g. 1971 and 1972a). Of particular interest is his observation that the command of heterogeneous structures is part of also unilingual linguistic competence and that consequently Chomsky and Halle's assumption of an ideal speaker-hearer in a homogeneous speech community prevents a realistic conception of language change. Very interesting is also his success in evaluating the relative contributions of the parameters age, style and social class in various cases of phonological change in progress.

A good many interesting positive contributions from a purely structural point of view have, of course, also been made during these years. A number of the papers given at the phonological conference in Vienna in 1972 belong to this category, but the proceedings of this conference have appeared so recently that I have not been able to utilize them (See Dressler and Mareš 1975). I should, however, particularly draw attention to a number of interesting and original papers by Henning Andersen (1969, 1972, 1973), treating various problems of diachronic phonology.

II. This is, I think, approximately where we stand. The next question: "What are our aims?" is more difficult to answer. In a very vague sense we may perhaps be said to have the same ideal, distant aim of arriving at a description which accounts for all important facts and generalizations, which can be used to explain things, and which corresponds to some type of psychological reality. But we may not all agree on what are the most important generalizations, nor what we want primarily to explain. And at the present stage of phonological research we should not conceal our lack of knowledge by proclaiming one theory and one method as the only correct one. Language is a complicated phenomenon, and various descriptions from various angles may be complementary rather than contradictory. What is needed is mutual tolerance and coordinate efforts.

But I think that, at the moment, many are interested in taking up the challenge of generative phonology concerning the psychological reality of phonological phenomena, and I should consider it one of the primary tasks of phonology in the coming years to attempt to come to grips with this problem. And in the remaining part of the paper I will deal particularly with this task.

III. Before trying to answer the question: "How can we approach our aim?", we must, however, stop for a moment and ask what is meant by "psychological reality". This is by no means clear.

It cannot, generally, be taken to mean "conscious awareness". For there are very few phonological phenomena of which naive speakers are consciously aware. One of them is the phonological difference or identity between wordforms. This is utilized in the usual pair test or commutation test. But even this knowledge may be defective. Labov (1972b) has recently observed that informants may be unable to distinguish minimal pairs which differ in their own pronunciation. The Russian linguist Panov (1967) has observed similar cases in Russian, and gives the following very plausible explanation: If many, or most, members of a speech community do not make a given distinction, it loses its communicative value, and even those who make the difference themselves stop taking notice of it. - Speakers are also generally aware of differences carrying social or stylistic connotations, and they are normally able to indicate the number of syllables in a word. They may also be willing to indicate the number of segments, but on this point they are usually so heavily influenced by orthography that their answers are extremely difficult to interpret.

But as soon as we get to the real points of disagreement between linguists (features, rules and underlying forms), no conscious awareness on the part of the speakers can be expected. What, then, do we mean by psychological reality in these cases? We can, as far as I can see, only mean that the speaker's linguistic behaviour seems to presuppose that he has, somehow, command of the units or rules set up by the linguist, or, to be cautious, of some equivalent of these units or rules. I shall (in agreement with the Danish psychologist Svend Erik Olsen) call this "functional psychological reality". It is very probable that the units or rules in question differ somehow as to psychological level, but I cannot see that we can say anything about this for the present.

As for the means to decide problems of functional psychological reality, we can draw inferences - with varying degree of safety - from various types of linguistic behaviour. This is nothing new, since most of these facts have been used in one or the other of the structural schools or in generative phonology as arguments for preferring one analysis to the other. A general list is found in a paper by Zwicky (1973). What we need now is a more detailed evaluation of what these sources can be used for. But I must content myself here with a brief survey, arranged in preliminary groups.

(1) There is first: normal linguistic behaviour - which has, of course, been utilized in all previous structural and generative statements about language. To take an example: Vowel harmony and other kinds of assimilation may give information about the distinctive features used by the speakers.

(2) The second group consists of various types of linguistic change: (a) Sound change may give information about the character of the pattern from which the sound change started: about the features, contexts or units that have been relevant for the change. This source has been utilized very much by Kiparsky (cf. also Schane (1971)). (b) The accomodation of loanwords is another very important source, giving information about possible segments, structural constraints and sometimes also phonological rules. (c) Acquisition of language by the child and learning of foreign languages by adults can be considered as a specific and very important type of change, from which inferences can be drawn concerning a number of different phenomena. It is important to observe both the strategy used by the child and the mistakes he makes.

(3) The third group comprises various speech errors: slips of the tongue, and aphasic disturbances. It is, for instance, an interesting observation that such errors generally respect the phonotactic surface constraints of the language.

(4) As a fourth group we may mention metrics and rhyme, phonetic puns and games and secret languages like pig-Latin.

(5) A fifth group consists of direct experiments. I shall return to some problems connected with this type of source in a few minutes.

(6) A last type of source is orthography. The invention of alphabetic script has often been mentioned as a proof of the reality of the phoneme. But this is a very sophisticated achievement which not every naive speaker can accomplish. The orthography of concrete languages and its development is, of course, our main source of knowledge about earlier phonological systems.

Orthographic errors are also of interest, and finally we may mention attempts at making illiterate persons construct an orthography for their mother tongue (cf. the famous experiments by Sapir).

The next question is, what we intend to infer from all these sources. Again here I shall try to set up some major groups of problems.

(1) It may be interesting, in the first place, to find evidence for the psychological reality of the various units set up by linguists: syllables, segments, features. (a) Are units of these different sizes stored somewhere in the brain of the speaker? Preliminary observations of speech errors (e.g. Fromkin 1971), as well as evidence from metrics, rhymes, puns and facts of assimilations and sound change, all bear witness to the existence of these units. Conclusions can also be drawn from experiments on speech sound perception, for example various tests of identification and discrimination (partly in the form of dichotic listening), or similarity judgments. Phonologists sometimes tend to ignore this information, perhaps because they think that it concerns performance and not competence. But we can only reach competence through performance, and the two should not be separated. (b) A somewhat different question is which particular segments and features are used by the speaker of a concrete language. Here the same sources may be used. Research is particularly needed to find out which features are used by the speakers. In this field the non-uniqueness of solutions is really confusing at present.

(2) The psychological reality of structural constraints is another important problem. Here loanword studies and experiments with nonsense words are particularly rewarding. It seems already pretty clear that surface structure is the decisive factor in the treatment of loanwords and also in judgments on the acceptability of phonological words.

(3) It is much more difficult to find safe arguments concerning the possible psychological reality of underlying forms and of phonological rules. There has been a strong tendency in generative phonology to set up underlying morphemes and rules leading from underlying morphemes to surface forms in all cases of alternation. But it is by no means obvious that this corresponds to the speaker's tacit knowledge. The first question to be posed when investigating psychological reality is whether a given linguistic regularity is synchronically productive or not, i.e., will the speakers apply the regularity to new linguistic material and to new combinations of linguistic material? External sandhi is a very appropriate field of study for this purpose, whereas word-internal assimilations (for instance in derivatives or inflected forms) cannot generally be used because the words may be stored as wholes. Such assimilations may, however (as mentioned by Rischel 1975), be informative in the case of polysynthetic languages like Greenlandic which have an almost unlimited possibility of suffixation involving obligatory assimilatory changes at the boundaries. In such language types the speaker simply cannot have heard and stored all possible combinations. Rischel mentions that there is a theoretical possibility that he has stored all possible dyads of morphemes, but since not all dyads constitute meaningful syntactic wholes, this is not very probable.

The productivity or non-productivity can, however, be more easily inferred from the treatment of loanwords. For interesting studies of this type, we may refer to Hyman 1970 (cf. the criticism by Linell 1974, p. 131 ff), Shibatani 1971, Skousen 1972 and 1973, Rischel 1975). Direct experiments may also be useful, for instance experiments in which informants are asked to make unusual derivatives of existing words (this type of experiment has been used by John Ohala (1972a and 1974a) and Manjari Ohala (1973)), or experiments with nonsense words, which, so to speak, function as artificial loanwords (this type has been used by

Ladefoged and Fromkin 1968, Zimmer 1969, and Hsieh 1970).

If the regularity is not found to be productive, it is hardly possible to get much farther. In this case, there are various possibilities: The speaker may have stored the alternating words as individual, unrelated words if the etymological relation is not very obvious (this may be the case with many derivatives and compounds). I think relatedness among words is far less obvious to the normal speaker and even to linguists, than often assumed in generative phonology. An English colleague of mine told me that she had not until recently realized that the word discover might be related to cover. And only a few days ago it occurred to me that plumpudding might have something to do with plums. If the speaker has not stored the words as unrelated, he may have stored them as related together with some phonological mechanism which he does not use productively, and in this case it is very difficult to say anything about what this mechanism is.

If, on the other hand, the regularity is found to be productive, then the possibility that the speaker has stored the forms as unrelated words can be excluded, and we can be sure that he has command of some type of phonological mechanism; the next problem will thus be to find out what sort of mechanism that is. This is by no means an easy task. He may have stored underlying morphemes together with rules, or he may have stored an alternation pattern operating between surface forms, and we must also make allowance for the possibility that he has a rule, but that some of the alternating forms belonging to the paradigm are also stored individually. And we must expect a good deal of variation among individuals according to their linguistic experience. It is not easy to devise experiments which can decide these questions. For instance, the fact that Ohala's informants seem to use analogy when presented with leading examples does not prove that they would use this method in other situations.

A particular difficulty involved in the use of nonsense words is that there may be different rules for native and foreign words; or a rule is only used productively for native words; and we cannot always be sure whether the informant will treat a nonsense word as foreign or as native.

Many precautions must be taken in this field if we want safe conclusions. Perhaps, for the time being, we must be glad if we can reach the modest aim formulated by Rischel (1975), that we should try to "distinguish regularities which are likely to be relevant to the way in which users of the language master it, from other possible generalizations which may be irrelevant from that point of view".

But it is certainly an attractive and important field of study. And we must hope that co-operation with psychologists may bring us some steps forward.

Finally, one question: What if we find out that the psychological reality is much more redundant and complicated than the descriptions linguists have aimed at up till now? This is not just an empty speculation. Recent research has shown that allophonic variation is in many cases not a peripheral mechanical phenomenon but planned in the innervation of the muscles and part of the speaker's unconscious knowledge of his language. What is then the correct description, or is there more than one? Must we set up one description which accounts for the facts in the most simple way without redundancy, and which may be useful for various descriptive and practical purposes, and one, more redundant description which corresponds more closely to speakers' reactions and which must be used for explanations, for instance of optimal phonological systems and of sound change?

Well, we must leave our mountain climbers where they are, hoping that with mutual help and openmindedness to suggestions from their co-climbers they may come closer to the peaks they are aiming at. - - But it may be that some of these peaks will forever be shrouded in fog!

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REGISTRATION OF VOICE QUALITY[1]

Børge Frøkjær-Jensen[2] and Svend Prytz[3]

Abstract:

Long-time-average-spectra recordings of normal voices as well as an average spectrum of such LTAS-registrations are shown and discussed.

For comparisons of voice qualities we have tried to set up a new parameter, α, which is a measure of the intensity relations in the higher and the lower parts of the speech spectrum:

$$\alpha = \frac{\text{intensity above 1000 Hz}}{\text{intensity below 1000 Hz}}^{4}$$

Because the spectrum above 1000 Hz is normalized relative to the spectrum below 1000 Hz, α is independent of microphone distance, amplification level, etc. α seems to be a good acoustic correlate to the physiological term "medial compression", and preliminary research indicates that it is relevant to evaluations and comparisons of voice qualities.

The "quality parameter" is represented graphically by histograms showing the number of α-values automatically sampled during a read text, and it is displayed on a storage oscilloscope along the vertical axis. The horizontal axis is used for displaying the total speech intensity.

We define voice quality as an auditory property, i.e. an aspect of the perception of the human voice. A good voice quality depends on (1) certain typical formant patterns, (2) absence of noise in the acoustic spectrum, and (3) a high degree of absence of aperiodicity in the fundamental frequency.

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1) Paper read at the International Congress of Phonetic Sciences in Leeds, August 1975. In the present version, only minor modifications have been made.

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3) Svend Prytz, M.D., Phoniatric Laboratory, ENT-department, University Hospital, Blegdamsvej, 2100 Copenhagen Ø, Denmark.

4) Cf. the paper by Svend Smith and Kirsten Thyme in this issue of ARIPUC.

In 1963 Wendahl and Moore found a direct relation between the jarring, rough, and hoarse voice quality in voices suffering from unilateral recurrent paralysis and the variations in periodicity between adjacent pitch periods.

Lieberman has defined these pitch variations in terms of the so-called Lieberman pitch perturbation factor, and he has analyzed the magnitude of this factor in different larynx disorders by computer.

Smith and Lieberman found significant differences between normal subjects and patients suffering from cancer of the vocal folds, polyps on or adjacent to the vocal folds, and acute and chronic laryngitis.

Koike improved this method and got similar results, whereas Hecker and Kreul could not reproduce Lieberman's results, even though the methods were almost identical. They defined instead a "directional pitch perturbation factor", which depends on the direction of the perturbation change. This factor was a significant improvement in the discrimination of pathological from healthy voices. Furthermore, they found a more narrow distribution of the fundamental frequency in pathological voices than in normal voices, and they established that the averaged fundamental frequency and duration of phonations were reduced compared to the normal voices. However, the patients used in this investigation were all selected and matched, and it was found that they all suffered from laryngeal cancer.

Hans von Leden and Iwata have investigated pitch perturbations (among other diseases) in 10 patients of unilateral recurrent paralysis before and after teflon®-injection in the paralysed vocal fold. They found the method reliable and useful in the phoniatric clinic. The discrimination between different laryngeal diseases was poor, however.

Just as important as the cycle-to-cycle variations in pitch is the acoustic structure of the speech spectrum. According to the literature, this spectrum has its origin in the voice source and decreases by 12 dB per octave. However, during normal speech we find variations in the slope. Glottography and inverse filterings seem to show that the slope for voiced consonants is about -15 dB per octave, and thus steeper than the slope for vowels. On the other hand, we find changes in the opposite direction during high voice effort, such as shouting.

Changes in voice quality are used by singers and actors as an artistic way of expressing their emotions and moods, whereas vocal disability as well as voice disorders create unpleasant voice qualities, such as breathiness, hoarseness, and roughness.

Within the phoniatric and logopedic clinic there is a great demand for developing instrumentation and methods for registration of changes in voice quality.

The present paper is a preliminary report, dealing with three different methods for voice quality analyses:

(1) Long-time-average-spectral analysis based on a read text of a duration of 45 seconds.

(2) Histograms of the voiced part of speech showing the amplitude level above 1000 Hz, relative to the level below 1000 Hz.

(3) The relative amplitude parameter shown as a function of the total amplitude level on a storage oscilloscope screen.

The analyzer used for the long-time-average-spectral analyses is a Brüel & Kjær 400 channel measuring system, which consists of a spectrum analyzer, an averager, and a 12" display with a level recorder for paper curve recordings. For further details we refer to the B & K manual and to our previous paper (Frøkjær-Jensen and Prytz 1974). In that paper we pointed out that the dynamic range of the instrument was too restricted for speech analysis. However, this problem was overcome by introducing a 6 dB per octave high shaping in the analyzed frequency range up to 5000 Hz. Furthermore, we have introduced a gating system which cuts out all voiceless speech segments. In this way the unvoiced sounds do not contribute to the total energy of the LTAS-analyses.

The first illustration (fig. 1)[1] shows four LTAS-analyses taken from 22 normal voices. Along the X-axis we have the relative amplitude level in dB. The dotted line indicates the above-mentioned preemphasis of +6 dB per octave. We observe deviations among the four voices. Especially for voices Nos. 2 and 22 we observe a pronounced depiction of the lower harmonics, which we may interpret as restricted variations in the fundamental frequency or intonation for these two voices. It may be due to the subjects' behaviour during the recording procedure. We do not find this harmonic pattern in voices Nos. 10 and 20.

The next illustration (fig. 2) shows the spectral distribution of 10 normal voices set up in the same graph. Notice the relatively small dispersion among the curves, which indicates that the spectral distribution of normal and healthy voices is fairly constant, at least up to about 3000 Hz.

In fig. 3 the solid line shows the average curve based upon the just shown 10 normal and healthy voices. The dotted line indicates the commonly presumed slope of -6 dB per octave of the radiated sound wave (voice source + radiation). As may be expected, we notice that the slope of the averaged speech spectra is steeper than -6 dB per octave.

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1) During the presentation of this paper, all illustrations were shown as slides, and sound samples from all voices shown on the slides were replayed from tape.

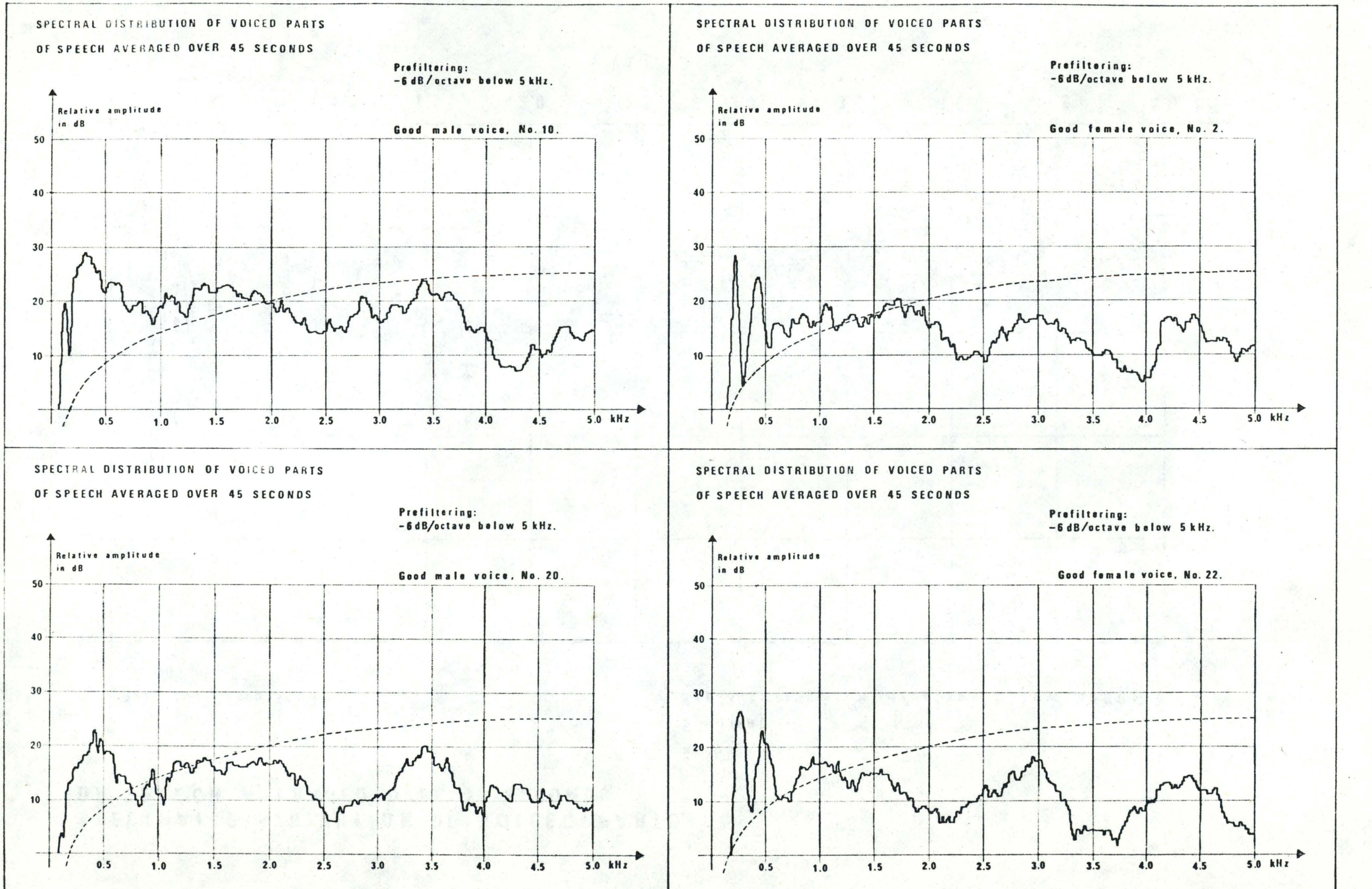


Fig. 1

LTAS-analyses of good and healthy voices.

SPECTRAL DISTRIBUTION OF VOICED PARTS
OF SPEECH AVERAGED OVER 45 SECONDS

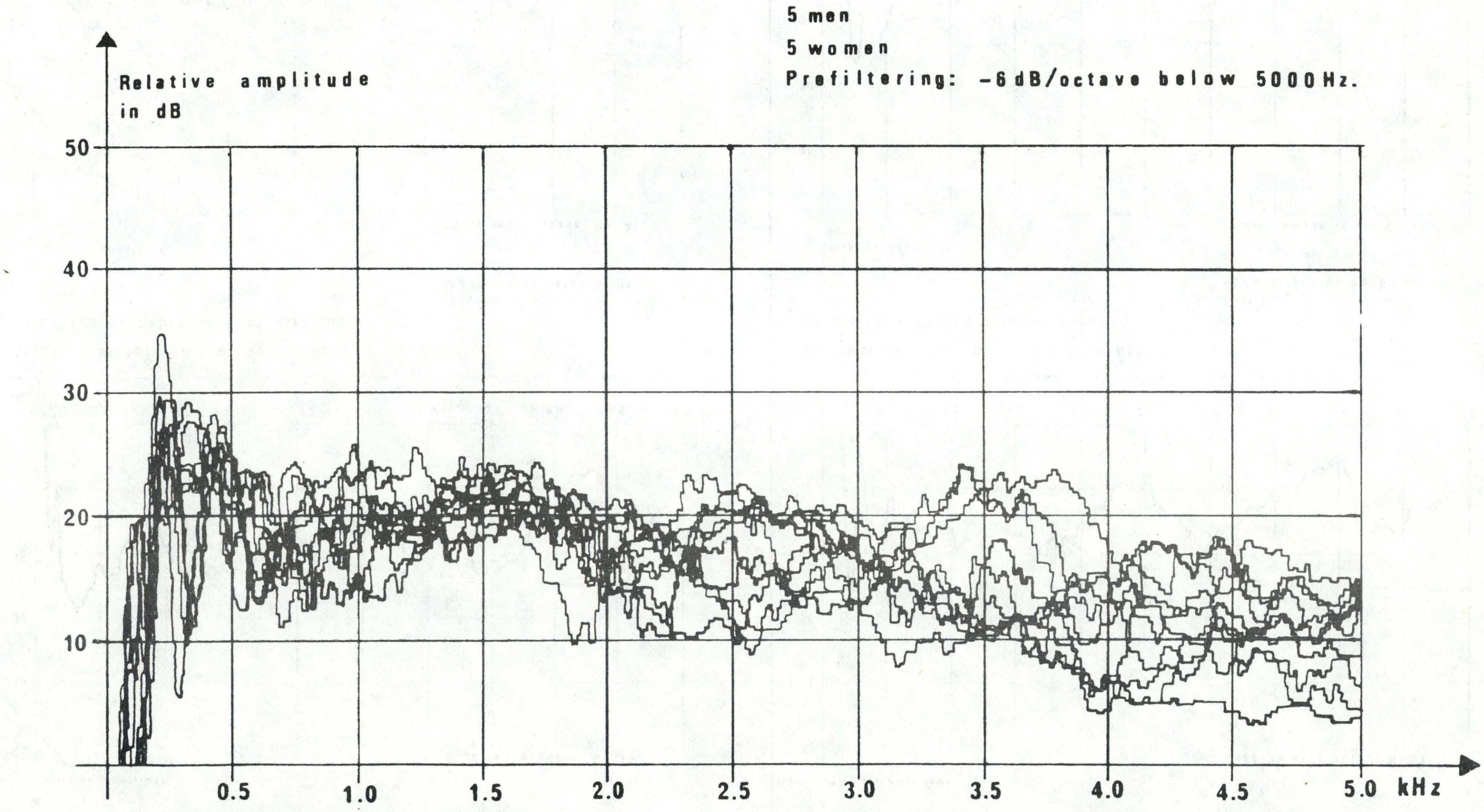


Fig. 2

SPECTRAL DISTRIBUTION OF VOICED PARTS
OF SPEECH AVERAGED OVER 45 SECONDS
FOR 10 GOOD VOICES

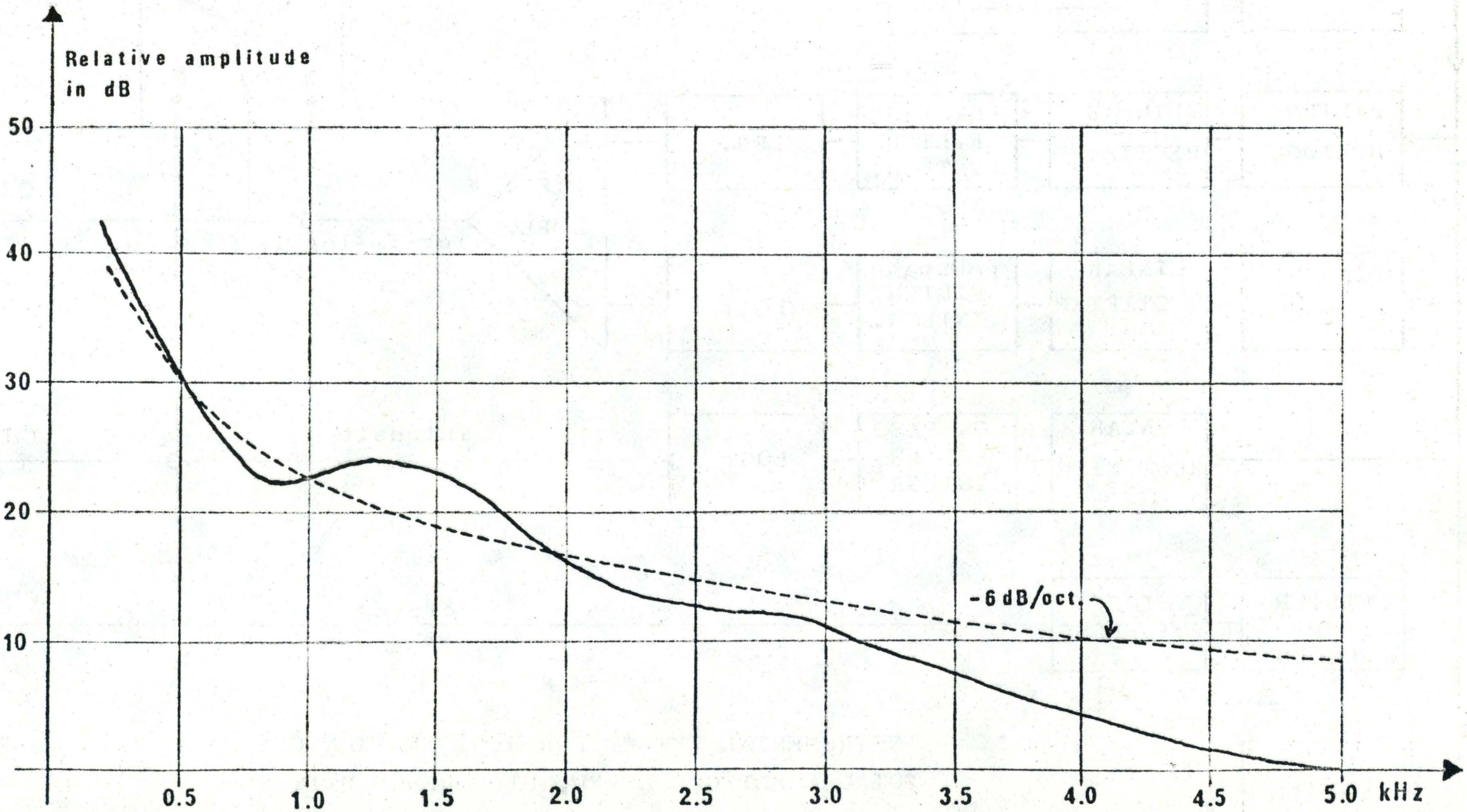
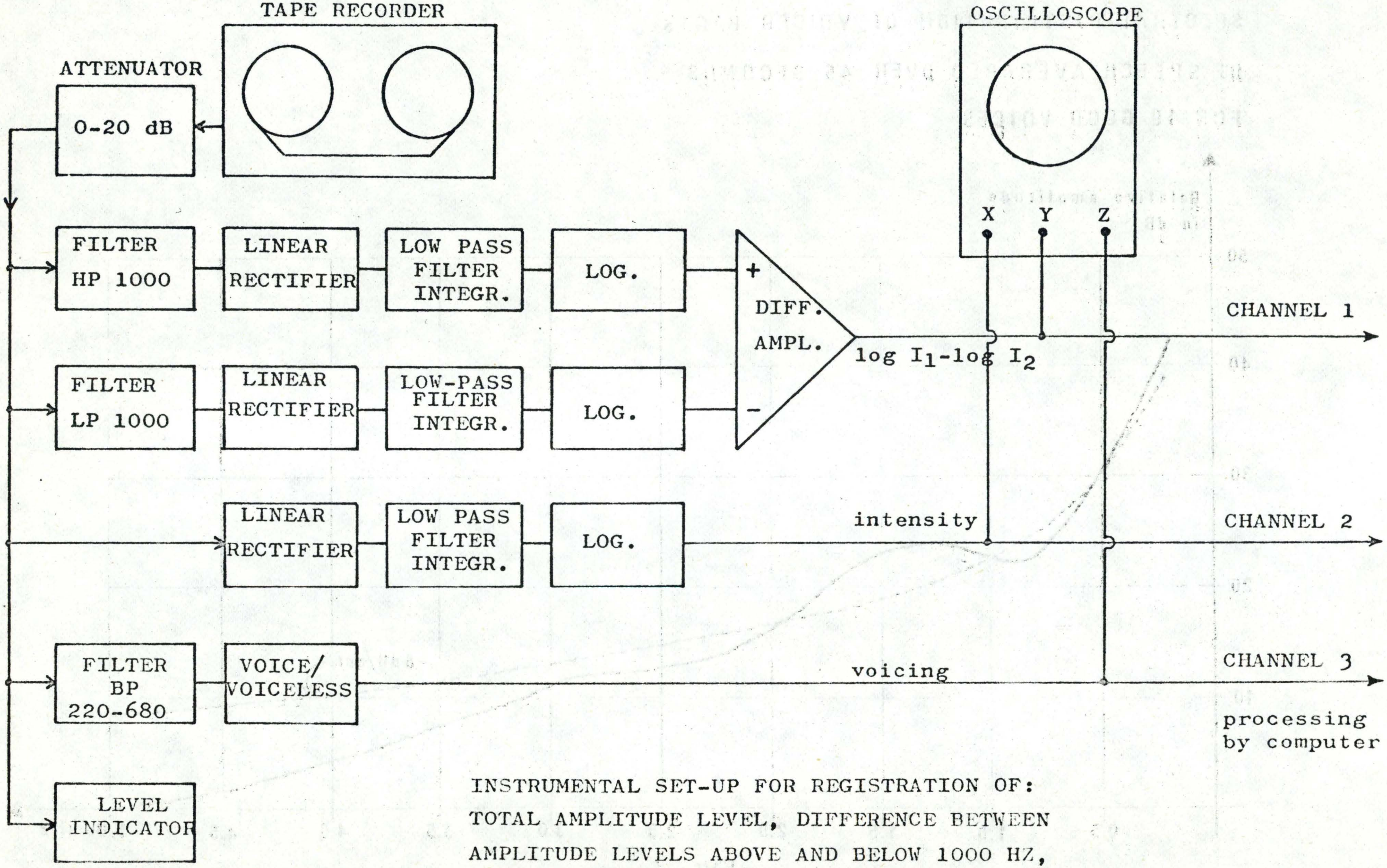


Fig. 3



INSTRUMENTAL SET-UP FOR REGISTRATION OF: TOTAL AMPLITUDE LEVEL, DIFFERENCE BETWEEN AMPLITUDE LEVELS ABOVE AND BELOW 1000 HZ, AND DURATION.

Fig. 4

Just around 800 Hz we find a zero in the radiated sound spectrum, but we cannot, based upon these recordings, decide whether this is due to less frequent occurrence of formant energy around this frequency, or whether it is due to a zero in the voice source.

In the previous illustrations we have shown some analyses of normal voices. The following graphs depict comparisons of voices suffering from unilateral recurrent paralysis before and after therapy - not for the purpose of showing what happens during the treatment of a given disorder, but merely to show how these analyses could be used for comparisons of the voice qualities.

For these comparisons we have tried to set up a new parameter, which we have called α.

We have defined

$$\alpha = \frac{\text{amplitude level above 1000 Hz}}{\text{amplitude level below 1000 Hz}}$$

$$\log\alpha = \log A \text{ (above 1000 Hz)} - \log A \text{ (below 1000 Hz)}$$

Because the amplitude above 1000 Hz is normalized relative to the amplitude below 1000 Hz, α is independent of the microphone distance, amplitude levels, etc.

Fig. 4 shows how the α-parameter is extracted from the tape recordings. In a differential amplifier we get the difference between the logarithmic voltages proportional to the intensity levels above and below 1000 Hz.

It does not matter whether we use intensities or amplitude levels, it will only be a question of calibration, because the intensities are proportional to the square of the sound pressure level.

The set-up includes a voice/voiceless indicator based upon a sensing of the energy in the F_1-region, and a full frequency logarithmic intensity channel.

The α-parameter is displayed on a storage oscilloscope as a function of the total intensity, where the light intensity of the oscilloscope is switched off and on by the voice/voiceless indicator.

α may also be recorded automatically 25 times per second and represented as a histogram by the computer.

Fig. 5 shows the LTAS-analysis and α-histograms of a patient with a phonatory hypofunction caused by recurrent paralysis before and after speech therapy. The graph shows how much the spectral amplitude has increased at different frequencies in the spectrum during treatment. - LTAS-graphs of phonatory hypofunctions often show that during speech therapy the energy is increased, except for the lowest part of the spectrum.

Examinations of LTAS-graphs from the voices of more than 50 patients and several normal subjects reveal that 1000 Hz seems to be a reasonable cut-off frequency for the above-mentioned comparisons between the higher and the lower part of the spectrum. This is in agreement with Ilse Lehiste, Gordon Peterson and Svend Smith.

The histograms of α before and after treatment in this illustration show an increase of about 4 dB for α.

In the next illustration (fig. 6), we notice an increase of about 3 dB during the speech training.

Fig. 4 above showed the instrumental set-up for recording the α-parameter. As it appears from that illustration, the -parameter could also be shown on an oscilloscope as a function of the total intensity. This is illustrated in fig. 7. The photos of the storage screen of the oscilloscope depict the α-parameter as a function of the total intensity, averaged over 20 seconds. In this illustration we have given three healthy and three pathological voices for demonstration purposes only.

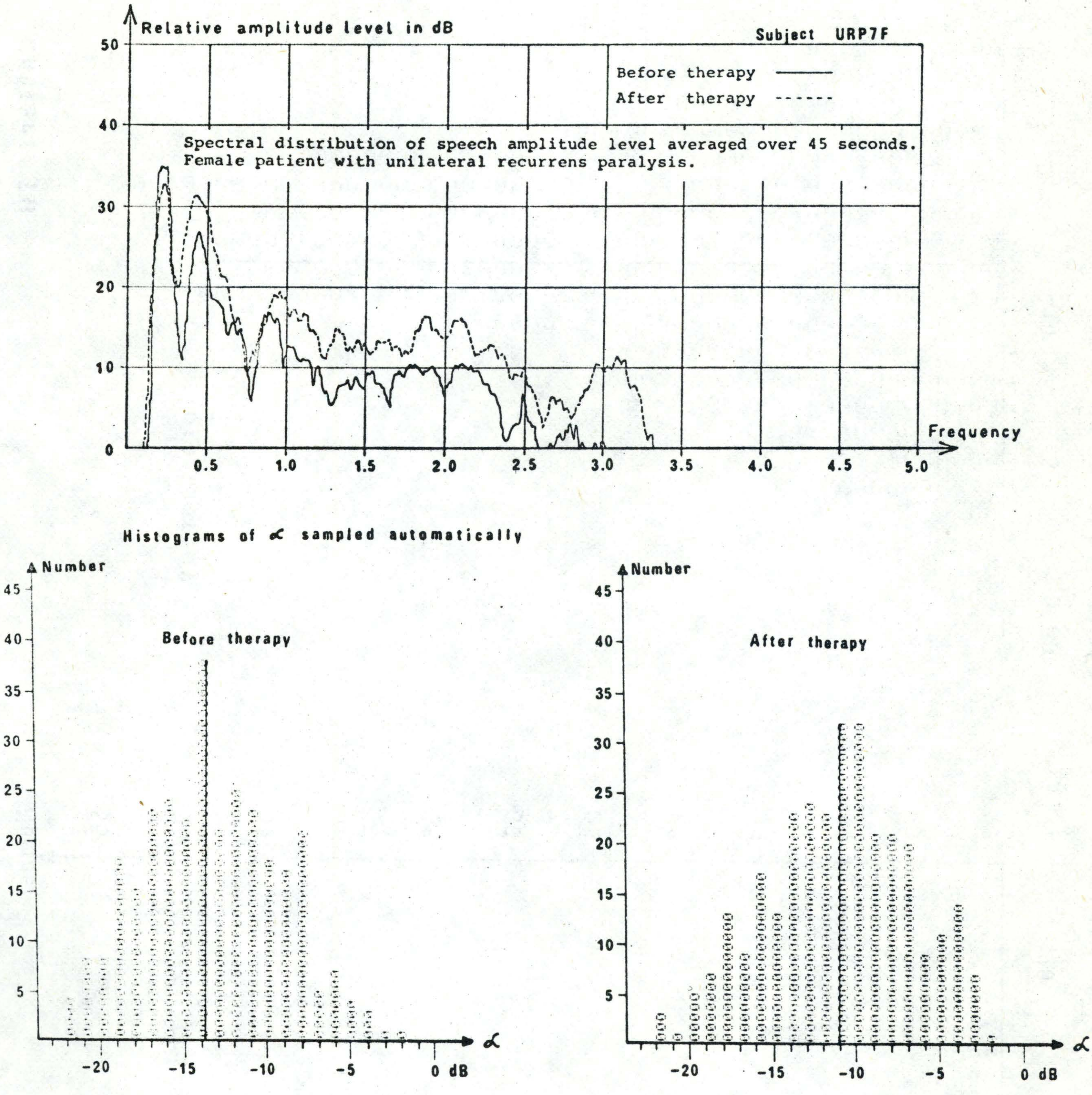


Fig. 5

Upper graph: LTAS-analysis of a patient suffering from unilateral paralysis before and after treatment.

Lower graphs: Distribution of the amplitude above 1000 Hz relative to the amplitude below 1000 Hz, sampled automatically 25 times per second.

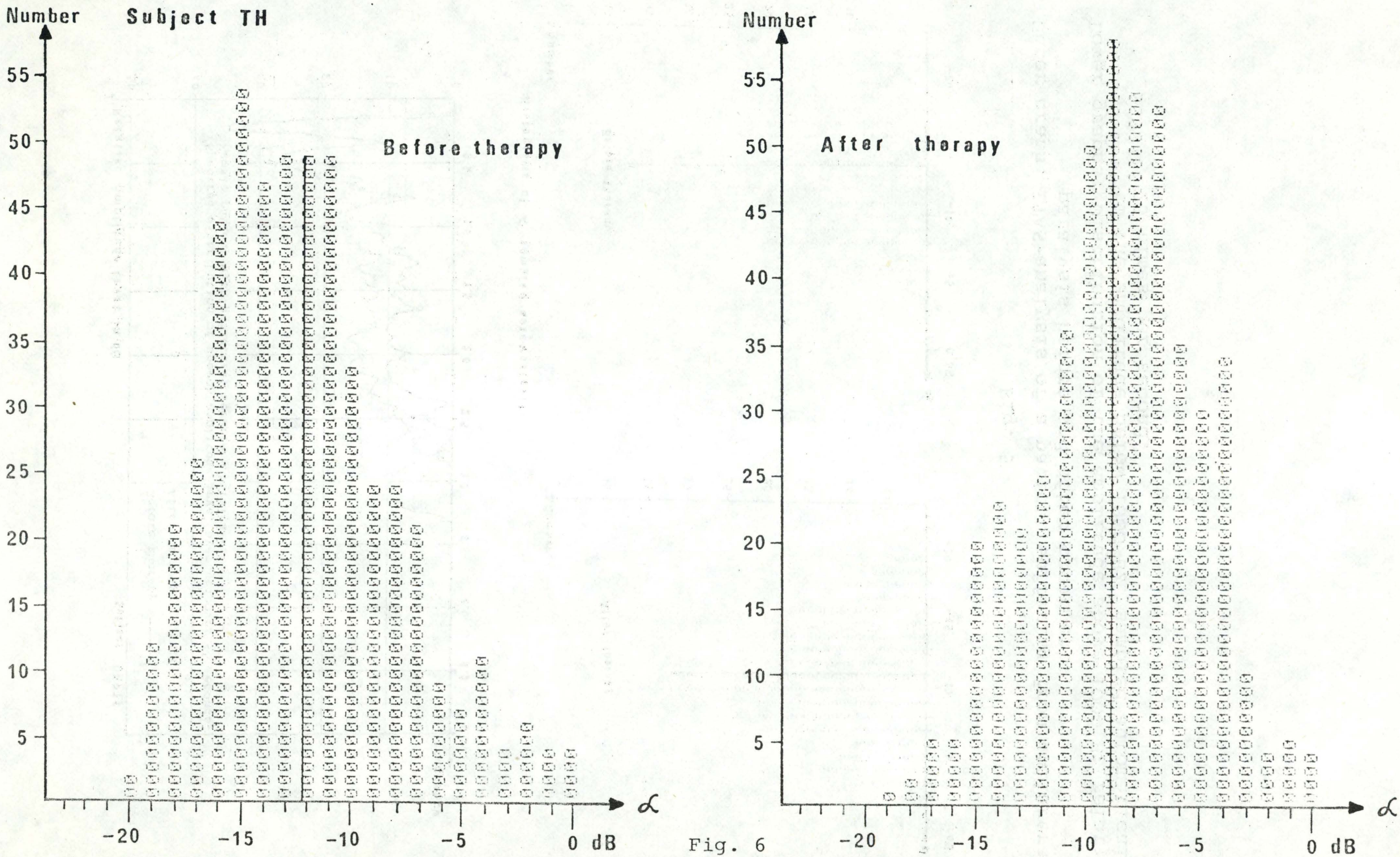
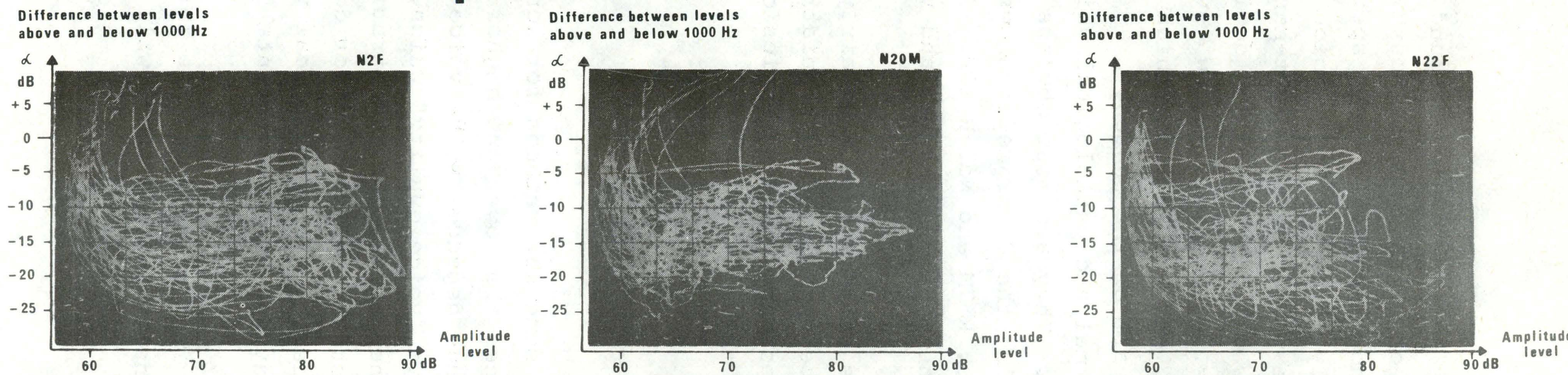


Fig. 6

Sample of α-graphs before and after speech training, showing an increase of about 3 dB of the spectral amplitude above 1000 Hz relative to the spectral amplitude below 1000 Hz

Good voice qualities:



Pathological voices:

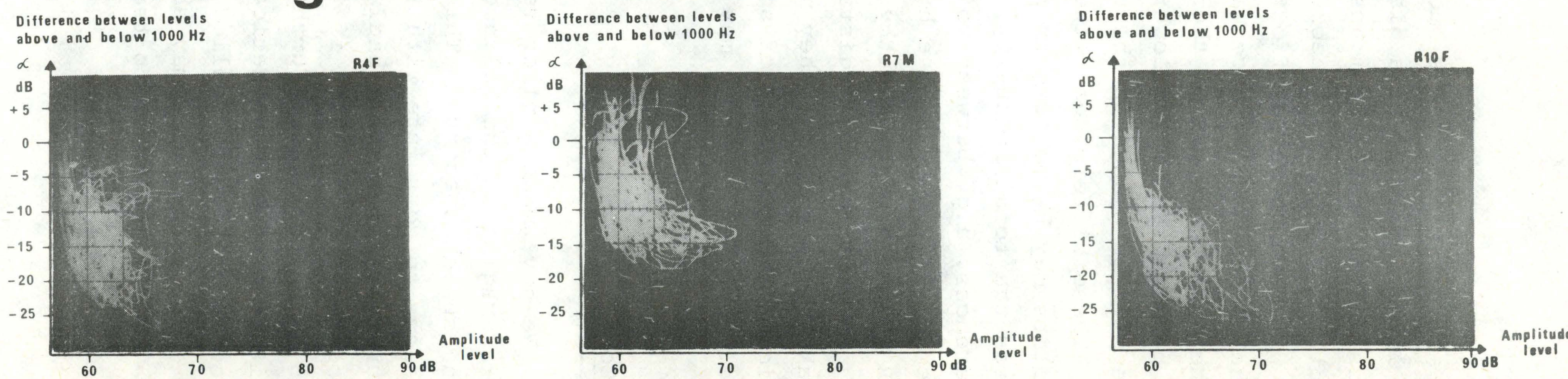


Fig. 7

Oscilloscope displays of total amplitude level (in dB SPL) and relative amplitude above 1000 Hz.

The X-axis in these photos is calibrated in dB sound pressure level, measured at a distance of 30 cm from the mouth. The Y-axis is calibrated by means of known synthetic vowel spectra and attenuated tones. Theoretically we may expect a voice phonating with a high voice effort to be placed in the right-hand part of the photos, and a voice with low voice effort to be depicted in the left-hand part of the photos. Voices with a low α-value will be depicted in the lower part, and voices with a high α-value will be placed in the upper part of the photos.

These differences between normal and pathological voice qualities may be noticed in fig. 7. They are most obvious as regards the total intensity, but also the α-parameter shows mutual differences, e.g. between voices No. R 7M and No. R 10F. In fact, voice No. R 7M sounds as a hyperfunctional dysphonia, and voice No. R 10F as a weak, breathy voice.

As oscilloscope registrations of this kind are fairly simple to make, it seems that they might be useful in the phoniatric clinic as a quick check of some important characteristics of the voice. Further research may prove this.

3. Conclusion

We have made a pilot test of some new methods for long-time-averaging of the balance between the lower and higher parts of the speech spectrum. This balance depends on the voice source and seems to correlate with the term "voice quality" which, unfortunately, is still a badly defined term. The registration methods seem to be valid if the acoustic spectrum is not dominated by white noise. Further research with pathological voice qualities produced synthetically may show to what extent the method is valid when applied to very noisy voices.

The coming years may show if registrations of the intensity above 1000 Hz relative to the intensity below 1000 Hz will turn out to be a useful aid in the phoniatric and logopedic routine diagnosis, as well as a tool for voice evaluation during speech therapy.

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TOPICS IN WEST GREENLANDIC PHONOLOGY

Jørgen Rischel

Abstract:

This is a brief presentation of the contents of the author's monograph (Rischel 1974).

1. Data and descriptive goals

In writing this monograph, I had two purposes in mind, viz. to contribute to the current debate about phonological theory, and to add to the available knowledge about Central West Greenlandic. I shall deal with the second point first (in section 2 below); the general phonological issues will be surveyed afterwards (section 3).

2. Information on West Greenlandic

The language under study is a dialect (or rather: a group of very closely related dialects) of Eastern Eskimo. It is spoken in part of West Greenland, and branches into Central West Greenlandic (henceforth CWG) and the more northerly dialect of the Disko Bay (and Uummannaq) area.[1] CWG is the norm stated in grammars, dictionaries, and textbooks, and moreover, it was available to me in the form of tape recordings and interviews with CWG speakers in Denmark. The phonology of the Disko Bay dialect was studied by the author on two field-work trips to Greenland in 1972. Both of these varieties of West Greenlandic: CWG and Disko Bay are referred to in the monograph, though the former is mostly used as the frame of reference (this is advantageous, firstly because CWG is more conservative on some points,

1) For a more precise listing of Greenlandic dialects, cf. my paper in this volume of ARIPUC (p. 1 ff).

and secondly, because readers will most often come across that variety in consulting the scholarly literature).

The information on West Greenlandic phonology in a broad sense (from phonetics to morphophonemics or morphology proper) is very uneven in the previous literature. My monograph (Rischel 1974, henceforth: TIWGrPh) attempts to present an assembly of the available knowledge about CWG phonology. Regularities are generally stated in much more detail than in previous sources, and various misconceptions prevailing in the scholarly literature are corrected. It may be mentioned that there is information on allophonic variation of vowels and consonants (mainly Part I, §§ 2.5 and 2.6), segment inventories (Part I, §§ 1 and 3; Part III, § 2), assimilatory phenomena and phenomena associated with syllabification (Part I: most of § 2), morphophonemic alternation (Part II), and morphological classification (Part III: § 3).

As far as prosodic phenomena are concerned, the information given in TIWGrPh (Part I, §§ 2.4.1 and 3.2) is partly new, partly based on quite recent studies by Robert Petersen, Hideo Mase, and the present author.[1] The information on prosody in the earlier literature is most fragmentary, and even in TIWGrPh this subject is treated only to the extent that it is relevant to segmental phonology. We are still vary far from possessing an adequate knowledge about Eskimo prosody.

Since it has become almost a tradition among American scholars to refer to Kleinschmidt's type of West Greenlandic in an alleged phonemicization of his 19th century orthography, I have devoted a good deal of space to an explication of the nature of that orthography. It is demonstrated (Part I, §§ 1.2.2, 2.1.2, and 2.3 p. 76-77) that Kleinschmidt himself worked on a certain level of phonological abstraction, and hence the linguist who thinks of his orthographical forms as a kind of raw-data on which one can freely build a superstructure of phonological abstraction, is involved in self-deception; the orthography itself represents a sophisticated linguistic analysis (p. 8).

1) See references in TIWGrPh p. 462.

There are especially two respects in which the monograph attempts to contribute to the solution of practical problems.

Firstly, there is a good deal of emphasis on systematic phonetic transcription (cf. Part I, §§ 1 and 3; Part III, § 1.1). The question of designing a phonologically adequate and at the same time versatile notation is a live issue in Eskimology, and it has come into focus in connection with the introduction of a new orthography for Greenlandic.

Secondly, morphological classification is approached with the intention of achieving both a simplification and a more rigorous treatment compared to earlier presentations. Formatives (morphemes) or formative clusters are viewed from two angles:

(I) Suffixes in the widest sense (i.e. postbases and endings) are characterized in terms of the behaviour of the segment stretch occurring at the transition from a stem to a suffix: there may be a deletion of material in the final part of the stem before the suffix in question; there may be a fusion of material from the stem and the suffix; there may be a simplification of suffix initial clusters under certain conditions, etc. (see Part II, § 1). These phenomena are (at least in part) idiosyncratic properties associated with individual suffixes (in my terminology: "left-hand properties", see TIWGrPh p. 405), and each suffix must be provided with appropriate labelling from which the morphophonemic behaviour of the suffix can be predicted. This was done by Kleinschmidt in his pioneer work[1] on Greenlandic grammar and lexicography, but later dictionary makers have skipped this information. Recently, the interest in this aspect has been revived on a scholarly level.[2]

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1) 1851, and 1873; references in TIWGrPh p. 462.

2) Most recently by Aagesen 1973; reference in TIWGrPh p. 460.

(II) Bases, postbases, and complex stems are, of course, considered in terms of the inflectional paradigms they belong to (in my terminology: "right-hand properties" of formatives, see TIWGrPh p. 406 ff). This approach is anything but new in itself: a variety of inflectional classes were distinguished already in the earliest Greenlandic grammars of the eighteenth century. However, my point is that all previous systematizations suffer from the defect that they fail to distinguish rigidly between morphophonemic phenomena which are automatically triggered by the segmental structure of the stems (bases, postbases), and phenomena which must be accounted for in terms of an abstract class-membership. And moreover, there is traditionally an undue emphasis on segment distinctions which are of very minor importance from the point of view of morphological class-membership. The classification I propose, involves three verb classes (with a subclassification of the first two classes). - As for nouns, traditional grammar fails to understand the paradigmatic interplay of phenomena such as consonant gemination, consonant truncation, metathesis, and vowel epenthesis or syncope, and the whole systematization has been hopelessly involved. The most important step towards an understanding of the nature of these phenomena was made by Knut Bergsland in his mimeographed grammar.[1] As a continuation of this trend I have arrived at what seems to me a meaningful organization (viz. two main classes of nouns, the first of which has two subclasses, and the second three subclasses).

3. Phonological theory

The whole approach is based on the assumption that it is a legitimate goal of phonological description to organize observations about wordforms in terms of regularities or "rules" (in a very general sense). There is no postulate about "psychological

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1) 1955; reference in TIWGrPh p. 460.

reality" involved in this. In my book I express the opinion that it is a very interesting and important goal to try to describe internalized grammar, but it is necessary - in my opinion - to discover and state the regularities that are common to speakers of a certain dialect before one can ask interesting questions about the way in which individuals master their language. Therefore, the book is neither intended to be an alternative to a psychological approach, nor a substitute for one, but possibly a prerequisite.

I have attempted not to commit myself as to "psychological reality" (except that I repeatedly point out that there are probably great differences among the representations of a dialect that are internalized by different individuals). - I attempt to characterize alternations in terms of their generality, but I do not measure "productivity",[1] and many issues are left open-ended for possible testing. Terms such as "productivity" and "lexicalization" are thus used in a quite provisional manner.

However, in the book I emphasize that it is the goal of a linguistic description to state the linguistically significant generalizations. I understand this to mean: regularities which may be relevant to the way in which speakers of the language master it. This is not tantamount to saying: the internalized rules of the informants employed. The descriptive linguist may strive to state a maximum set of regularities which meet some general criterion of linguistic significance (unfortunately, we do not have a theory defining such a criterion yet), but even if he should succeed in doing so, he still would not be describing what is inside the heads of individual speakers.

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1) Some pilot attempts which I made in 1970 to test the prognostic validity of certain rules in the speech of Greenlandic school-children, were methodologically too primitive, and I skipped the approach at that time.

In the book surveyed here, I have attempted to delimit an "interesting" set of regularities in a different manner, viz. by (immanent) functional considerations. I claim that there is a set of phonological rules which jointly adjust the wordforms to meet certain well-formedness conditions. The pervading tendency here is simplification of surface phonotactics: preferred syllabification, co-occurrence restrictions, generalization of certain types of segments in final position. The rules in question, together with the phonotactic generalizations involved in the well-formedness conditions, are supposed to form a functional core of West Greenlandic phonology. In describing this component one automatically bridges the gap between structural and generative approaches. I have employed the terminology of transformational generative phonology in stating the rules etc., but it is emphasized that this is essentially a choice of format of description, not a manifestation of "belief" in the current descriptive framework as such.

There are several morphophonemic regularities which fall outside the functional core of West Greenlandic phonology. It is interesting to notice that these allegedly more peripheral regularities include some of the phenomena which are much discussed in the current literature (e.g. "gemination", which is often discussed as if it were a productive mechanism in West Greenlandic, although it is clearly on its retreat in modern language).

There is a certain time perspective in the distinction between rules inside and outside the functional core in contemporary West Greenlandic: the former are largely regularities which have come into force after an orthographical tradition was established in Greenland in the 18th century, and which are still only on the point of entering the northenmost dialect of Greenland (examples in Part I, § 2), whereas the latter are phenomena belonging to a relatively old stratum.

In general terms, I argue that morphophonemic phenomena which are "unnecessary" from the point of view of the complex surface conspiracy, are doomed to end up, sooner or later, as morphological and lexical idiosyncracies. In Part III, § 1 it is suggested that some observed regularities of this kind are statable as rules which apply restrictedly (to forms marked for their application) but have the formal properties of replacement or deletion rules, whereas others are handled more adequately in terms of alternations (which are often statable in terms of "ambivalent" morphophonemes, p. 342-353). Both kinds of rules are "morphophonemic", in contradistinction to the functional core of phonological rules.

As for the issue of rule ordering, my focus on clearly functional rules makes it superfluous to posit considerable depths of mutual ordering or cyclical rule application. I propose (Part III, § 1.2.1) a distinction between phonological rules (for which I assume a version of the "local ordering" hypothesis, although I do not take a very definite stand on this issue) and phonetic rules.

Phonetic rules are supposed to be "anywhere rules" which just state how a given form is to be interpreted phonetically (i.e., allophonic rules, or manifestation rules, of a rather traditional kind). There is, according to this conception of phonetic rules, a phonetic interpretation associated with a form, no matter whether the form in question is supposed to be "underlying" in respect to some other representation, or not. This, together with the contention (Part III, § 2.2) that there is no difference in principle between "underlying" and "surface" segments (except for ambiguous morphophonemes), more or less eliminates the compartmentalization prevalent in much of modern phonology.[1] For example, the plain and pharyngealized (uvularized)

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1) There is a graph on p. 364 which might convey a different impression, since it fails to bring out my contention that representations have a phonetic interpretation no matter whether they are more or less abstract.

varieties of /i/ are supposed to be united by a pattern of reversible phonetic rules. In a formative final stretch /iq/ the vowel is pharyngealized, but if /q/ is deleted the vowel is reinterpreted phonetically in accordance with the new environments. Similarly, formative-final /i/ is non-pharyngealized, but if it comes to stand before (suffixal) /q/, it is automatically reinterpreted as a pharyngealized vowel. Thus, phonetic rules are recessive in relation to other mechanisms such as segment deletion rules.

Altogether, my analysis of West Greenlandic phonology does not lend support to claims about the necessity for fancy machinery, as long as one keeps to the rules which have to do with the fulfillment of well-formedness conditions on phonological strings. The emphasis, I claim (Part III, § 4), must be on the observation of <u>constraints</u>. The question whether complex endings, for instance, can be generated from simpler formatives (in more or less agreement with the diachronic development by which they were amalgamated) is synchronically of marginal interest, except if there is some more general phonological motivation for the rules that one must posit in order to generate the forms in question.

As mentioned earlier, the analysis is essentially immanent, i.e., the results are not generally verified by external evidence such as psychological experiments, observation of children's language, or linguistic change, although evidence of these kinds is occasionally referred to. It is crucial to confront such a description with substantial evidence. In particular, I emphasize that it is interesting to study the processes by which loanwords have been accomodated to the constraints of the Greenlandic language. One notices that firstly the accomodation of loanwords involves processes which are <u>not</u> motivated in statements about native forms, and, secondly, there is nothing in the behaviour of forms made up of native formatives which matches the fact that loanwords now enter the language with less modification than they did a century ago. Some constraints have been slackened vis-à-vis loanwords, though they are still valid for wordforms made up of native formatives. This question of dynamic versus static regularities is a crucial issue for contemporary phonological theory. The monograph ends with a statement to that effect (p. 437).[1]

Acknowledgements:

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References:

Rischel, Jørgen 1974: Topics in West Greenlandic Phonology (Akademisk Forlag, Copenhagen). 478 pp.

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1) I wish to add now that the matter is more involved than indicated in my book. Consonant assimilation of /kt/ to [tt], for example, is absolutely valid at formative boundaries, but loanwords are admitted nowadays without assimilation of internal clusters such as /kt/. Altogether, foreign formatives tend to escape the rules operating on the native vocabulary by obeying rules of their own. Since /immuk+tu^{r}ppuq/ 'milk-drinks' has assimilation of /k+t/ to [tt], one might expect the same from a construction involving the base 'ammoniac' plus /tu^{r}ppuq/ 'drinks'. However, the base is borrowed in the form /amuni^{j}akki/ (although /amuni^{j}ak/ would be structurally possible), and thus escapes the assimilation rule. This strange interplay of rules for native formatives and adaptation rules for foreign formatives is indeed a crucial issue.

REPORTS ON WORK IN PROGRESS AND PILOT STUDIES

FURTHER WORK ON COMPUTER TESTING OF A GENERATIVE PHONOLOGY OF DANISH

Hans Basbøll and Kjeld Kristensen[1]

1. Introduction

The purpose of the project to be reported here (called "DANFON") is that of a computational testing of a generative phonology of Danish (which, in its main lines, was already worked out by one of the authors, HB, before the project started). The ultimate purpose is that of improving the generative description of Danish phonology which is being tested, and also that of expanding the coverage of this phonology (see further section 5 below). The reader is referred to Basbøll and Kristensen 1974 for an account of the general structure of program and organization of data. Only points which were unmentioned in the previous report, or which have been changed since this report, will be included in the following (very preliminary) survey.

2. Some phonological aspects of the project

A string in abstract phonological representation is the input, and the program then changes it to an output (or several outputs) in phonetic (IPA) notation, by successive application of the phonological rules contained within the "grammar". The grammar makes use of three sets of background data, viz. UNIT-MATRIX (whose two dimensions consist of the distinctive features

1) Kjeld Kristensen is an engineer and cand. phil. in Danish. He teaches at the Institute of Scandinavian studies (University of Copenhagen). - We are indebted to Peter Holtse for valuable discussions, and to Jørgen Rischel for stylistic suggestions.

and the inventory of units, i.e. phonetic segments and boundaries, see sections 2 - 2.1 below), RULEMATRIX (whose two dimensions consist of the distinctive features and the (incompletely specified) units defining the structural description and change of each phonological rule), and RULEINDEX (which gives general information on each phonological rule concerning optionality, sensitivity to syllable boundaries, and the location of the rule in RULEMATRIX). See section 3.2 below for the description of a RUN, and, for further details, Basbøll and Kristensen 1974.

The phonetic notation used for the output forms must be narrow, since we want to be able to distinguish between <u>all stylistically relevant</u> phonetic differences (due to our interest in the possible hierarchy of <u>optional</u> rules). We therefore operate with 89 distinct phonetic segments ("sound symbols"), for the moment. These are listed below (in IPA-notation; for practical reasons[1] we are forced to use wrong symbols in some cases which will be indicated directly below). The first sixteen symbols (viz. those denoting full vowels) occur both as long and short vowels, and both with and without stød (see section 2.3 below); the number of non-composite IPA-symbols below therefore reduces to 89 - 3x16 = 41. The grammar operates with two further units, viz. the syllable boundary ($ on the line printer, ˇ on the IPA ball-head) and a grammatical boundary (# on the line printer, / on the IPA ball-head), see further section 2.1 below. Notice that all these phonetic segments and boundaries are used on most levels of the derivation: many of them occur as abstract phonological segments, and all of them as phonetic segments (and as intermediate segments).

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1) Partly because the correct symbols are not found on the IPA ball-head, partly because certain characters on the papertape typewriter are prohibited in normal use (for computational reasons).

Phonetic segments:

(1) 16 full vowels:

i e ɛ æ ɑ

(e.g. in bil 'car', lidt 'little, adv.', fæ 'fool', hane 'cock', varm 'hot' [bi·ʔl, led, fɛ·ʔ, hæ·nə, vɑ·ʔm])

y ø œ ɵ (for Œ, i.e. a low rounded front vowel)

(e.g. in dyst 'fight', løb 'run', høne 'hen', grøn 'green' [dysd, lø·ʔb, hœ·nə, gʁŒ nʔ])

u o ɔ ɷ (for ɒ)

(e.g. in mus 'mouse', kone 'wife', blå 'blue', år 'year' [mu·ʔs, ko·nə, blɔ·ʔ, ɒ·ʔ])

a ɤ (for ∝, i.e. a vowel intermediate between a and ɑ) ʌ

(e.g. in land 'country', lam 'lamb', hånd 'hand' [lanʔ, l∝mʔ, hʌnʔ])

(2) 3 weak vowels:

ɩ[1] ɨ[2] ə

(e.g. in dydig 'virtuous', madding 'bait', hoppe 'hop' [dy·ðɩ, maðɨŋ, hʌbə])

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1) The symbol ɩ denotes a "weak i" (derived from /ə/ by vowel raising before velars) which is found in the derivative ending -ig. If this sound is phonetically identical with a normal [i], a late tensing rule: ɩ ⟶ i may be included in the grammar (cf. the following footnote).

2) The symbol ɨ denotes a "weak e" (derived from ɩ by vowel lowering before nasals) which is found in the derivative ending -ing. If this sound is phonetically identical with a normal [e], a late tensing rule: ɨ ⟶ e may be included in the grammar (cf. the preceding footnote).

(3) 3 non-syllabic components of diphthongs:

j w ɹ

(e.g. in <u>jeg</u> 'I', <u>tov</u> 'rope', <u>bær</u> 'berry'
[jɑj, tɒw, bæɹ])

(4) 13 obstruents:

p t k

(e.g. in <u>på</u> 'on', <u>te</u> 'tea', <u>kom</u> 'came'
pɔ·?, te·?, kʌm?])

f s ʃ h

(e.g. in <u>få</u> 'get', <u>så</u> 'saw', <u>sjæl</u> 'soul', <u>hund</u> 'dog'
[fɔ·?, sɔ·?, ʃɛ·?l, hun?])

b d g

(e.g. in <u>ben</u> 'bone', <u>dyr</u> 'animal', <u>gå</u> 'walk'
[be·?n, dy·?ɹ, gɔ·?])

v ʁ ʀ (for ʁ̥)

(e.g. in <u>vild</u> 'wild', <u>rå</u> 'raw', <u>kors</u> 'cross'
[vil?, ʁɔ·?, kɒʁ̥s[1]])

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1) We have chosen to operate with a separate symbol for the unvoiced ʁ in the sequences <u>rp</u>, <u>rt</u>, <u>rk</u>, <u>rf</u>, <u>rs</u> (as a phonetic notation, this applies only in very conservative standards, of course). The point is that these sequences generally do not have "stødbasis" in conservative standards (this state of affairs is now in the process of change); compare the fact that words like <u>kors</u> [kɒ·s] in modern pronunciation violate the general restriction that monosyllables with a long vowel have stød. Notice, however, that we use the normal r-symbol, viz. ʁ, in the phonetic notation of words like <u>pris</u> 'price' [pʁi·?s] which phonetically have unvoiced ʁ, just as we use the normal (voiced) symbols [j l v], etc. also after [p t k f s] in words like <u>pjat</u> 'nonsense', <u>klo</u> 'claw', <u>tværs</u> 'across' [pjad, klo·?, tvæʁ̥s/tvæɹs]. This is because we consider (in agreement with Peter Holtse) the devoicing after "aspirates" to be a purely phonetic process, the aspiration phase being concurrent with the articulation of the following consonant.

(5) 6 non-syllabic sonorants:

l m n ŋ

(e.g. in lys 'light', mus 'mouse', nå 'reach', lang 'long' [ly·ʔs, mu·ʔs, nɔ·ʔ, lɑŋʔ·])

ð ɣ

(e.g. in fed 'fat', fag 'profession' [fe·ʔð, fæ·ʔɣ])

2.1 Distinctive features

The 89 phonetic segments listed above, together with the two boundaries (and the blank), are cross-classified by 18 distinctive features which will be mentioned below. The choice of features as well as the feature analysis of the segments must be considered very preliminary. In particular, we may want to change this part of the grammar as a result of the attempted coordination with Peter Holtse's project in progress of synthesis by rule of Standard Danish. Reference to the voluminous literature on distinctive features will generally be omitted here.

The 18 distinctive features are the following:

Unit: All segments and boundaries are [+unit]; a blank (in the output from a deletion rule) is [-unit], see Basbøll and Kristensen 1974, p. 220.

Segment: Boundaries are [-segment], all other units are [+segment].

Grammatical boundary: The grammatical boundary (# or /) is [+grammatical boundary], the syllable boundary ($ or ˅) is [-grammatical boundary]. All segments are unspecified for this feature, viz. [0 grammatical boundary].[1]

Syllabic: Full and weak vowels are [+syllabic], while obstruents, consonantal sonorants and [j w ɹ ð ɣ] are [-syllabic]. Our general treatment of "syllabicity" is explained in section 2.2 below.

Sonorant: [sonorant] is defined as an acoustic/auditory concept, in agreement with Ladefoged 1971. [p t k f s ʃ h b d g v ʁ ɡ̊] are [-sonorant], i.e. obstruents, all other segments being [+sonorant].

Constriction: [constriction] is a ternary feature indicating the maximal constriction in the primary speech channel. Nasals and oral stops are [3 constr] (the same applies to trills, taps, etc.). Fricatives are [2 constr], and vocoids, [l] and [h] are [1 constr]. Our use of this ternary feature corresponds to Ladefoged's distinction between stops (i.e. [3 constriction]),

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1) At the moment, we consider the possibility of changing the grammar so that it can operate with the notion of rank of boundaries (and, hence, rank of rules) as suggested by McCawley, see Basbøll's paper on grammatical boundaries in this volume, particularly pp. 111 f and 119 ff. According to this proposal the binary feature [grammatical boundary] should be replaced by a multivalued feature [boundary], possibly so that $ (or ˇ) is [1 boundary], the intra-word (strong) grammatical boundary (identical with the (weak) inter-word boundary) # (or /) is [2 boundary], the (strong) inter-word boundary ## (or //) is [3 boundary], and the "sentence boundary" (loosely speaking), viz. ### (or ///) is [4 boundary]. Our notion of $-sensitive versus $-insensitive rules could thus be generalized in such a way that each rule gets its rank specified as [1 bound], [2 bound], etc., by means of an index (1,2,3, or 4) in RULEINDEX, which replaces the present binary distinction of $-sensitive and $-insensitive rules. In the case of a rule of rank 3, boundaries of ranks 1 and 2 (but not boundaries of ranks 3 and 4) should thus be ignored when the compatibility of an input string with the structural description of this rule is examined. From a phonological point of view, this proposed change in our treatment of boundaries seems very attractive. (The fact that zero is compatible with all numbers in our treatment of rule application makes it necessary to keep the distinctive feature [segment], also when the change proposed in this note is carried out.)

fricatives (i.e. [2 constriction]), and approximants (i.e. [1 constriction]); Ladefoged, however, uses the binary features [stop] and [fricative] which permit him to characterize the affricates as [+stop, +fric] (thus in this case ignoring the time dimension). One of the major justifications of the ternary feature [constriction] is that [h] can then be given a reasonable definition, viz. as a voiceless (i.e. [-gl constr]) sound which is [1 constr].[1] It should be noticed that this use of [constriction] permits the inclusion of [1 constr] in the hierarchy of features accounting for the maximal syllabic structure (see Basbøll 1974), at the place between [-consonantal] and [+sonorant], presupposing that [h] is disregarded at the establishment of the hierarchy.[2]

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1) The ternary feature [constriction] replaces the traditional feature [continuant], [-continuant] being equivalent with [3 constriction]. The distinction between [2 constr] and [1 constr] recalls the distinction between obstruents and sonorants ([2 constr] sounds always being [-sonorant], whereas [1 constr] sounds are normally [+sonorant]), with the important reservation that [h] is [1 constriction] and voiceless, and thus an obstruent, at the same time.

2) [h] is the only Danish segment which is completely non-combinable with any non-syllabic segment, and it thus does not enter into any ordering relations among consonants. This particular status of [h] is codified in the phonological works of Uldall (1936) and Martinet (1937) who consider [h] a prosody (Martinet treats [h] as a breathy attack of (stressed) vowels, which enters the correlation of aspiration: /p, t, k, h/ : /b, d, g, zero/).

The main weakness of our use of the ternary feature [constriction] is that the class of "voiced continuants" cannot be defined as a natural class in the technical sense. This class seems relevant in phonotactics, since the segments which may occur in the vowel-adjacent position in a word-initial three-consonant cluster are [j l ʁ v] (notice that [j] is a non-consonantal sonorant, [l] a consonantal sonorant, and [ʁ v] voiced obstruents). One possible solution is to define this class in terms of <u>two</u> very natural classes, viz. the class of non-syllabic voiced segments <u>minus</u> the class of [3 constriction] (i.e. non-continuant) segments. This is not quite satisfactory, of course.

Lateral: [l] is the only sound which is [+lateral].

Consonantal: [consonantal] is here used as a cover feature (in the sense of Ladefoged), i.e. as a feature which is defined exclusively by means of independently established features. [-consonantal] is defined by the equivalence: [-consonantal] ≡ [+sonorant, 1 constriction, -lateral], and, consequently, the class of all [+consonantal] sounds is the union of the (non-overlapping) classes of obstruents (i.e. [-sonorant]; as mentioned above, all [2 constr] sounds are obstruents), laterals, and non-continuant sonorants (viz. [+sonorant, 3 constr]), i.e. (mainly) nasals. For further details, see Basbøll's paper on diphthongs in this volume, p. 49 ff (as mentioned above, [+continuant] and [1 constriction] are equivalent in the formula).

Glottal constriction: [p t k f s ʃ h ɣ̊] are [-gl constr], all other segments are [+gl constr]. Notice that [b d g], which phonetically are voiceless (in the traditional sense, i.e. the vocal cords do not vibrate) and distinguished from [p t k] by means of aspiration, are [+gl constr], which agrees well with the results of Frøkjær-Jensen, Ludvigsen and Rischel 1971, as well as with several phonological patterns (in most cases, [gl constr] is identical to the traditional feature [voiced]).

Labial activity: Rounded vowels, including the weakly rounded [ʌ], are [+lab ac]. The same applies to consonants with labial (primary or secondary) articulation, i.e. [w, p, f, b, v, m]. All other phonetic segments are [-lab ac], except [j ɹ h] which are unspecified for this feature.

Apical: [t s d l n ð] are the only sounds which are [+apical].

Back: The normal vowel space is here analyzed by means of two dimensions: [back] and [distance] (measured from the maximally constricted pharyngeal vowel, see below), in addition to [labial activity], as mentioned above (see fig. 1). A vowel is

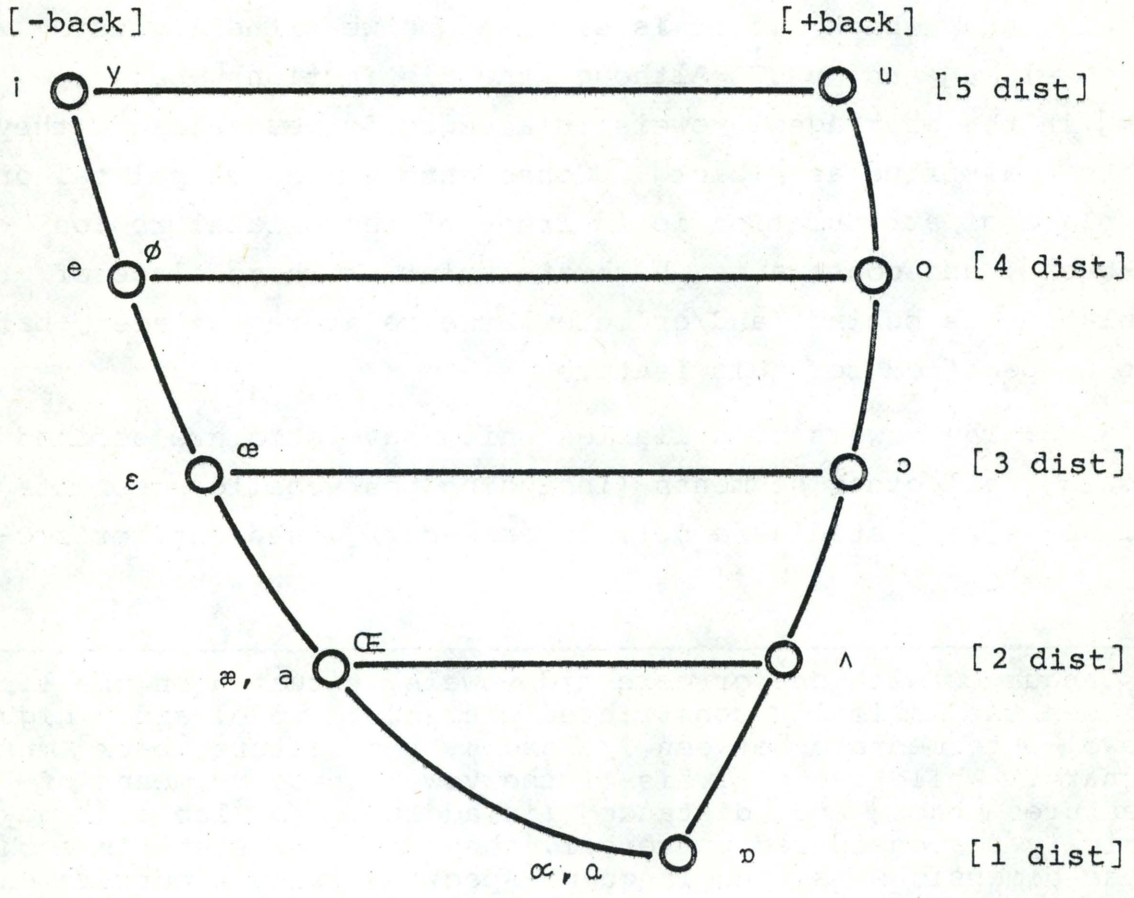

Figure 1
Schematic drawing showing the relationships between the vowels in terms of the features [back] and [distance] (see section 2.1).

[-back] if it is situated on the "left and bottom side" of Jones' Cardinal vowel diagram, i.e. between the highest and most front palatal vowel [i] and the lowest and most back pharyngeal vowel [ɑ], and [+back] if it is situated between the highest velar vowel [u] and [ɒ].[1] Although the distinction [-back]: [+back] in the pharyngeal vowels in a sense is neutralized, they are here classified as [+back]. Consonants which are palatal or whose place of articulation is in front of the palatal region are [-back], and consonants which are velar or whose place of articulation is behind (and/or below) the velar region are [+back]. [h] is unspecified for this feature.[2]

<u>Stød</u>: The vowels of syllables which have stød are defined as [+stød], all other segments (including postvocalic sonorants in syllables with stød) are defined as [-stød], see further section 2.3 below.

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1) In languages with one or more mid vowels, situated on the line between the maximally constricted pharyngeal vowel and a high mid vowel intermediate between i/y and u, the feature [back] must be ternary. While the analysis of the vowel space by means of the features [back] and [distance] (in addition to [lab ac]) may tentatively be considered universal, the number of steps in each of these dimensions is thus language-specific (within certain universally determined limits, of course).

2) The features [lab ac], [apic] and [back] together seem to cover the traditional dimension "place of articulation". We have, in fact, considered the possibility of operating with a multivalued feature [articulation place] instead, with the coefficients 1 (= labial), 2 (= dental), 3 (= palatal), 4 (= velar), and 5 (= pharyngeal). However, we should still need an independent feature for rounding (cf. the labio-velar glide [w], derived from labi(odent)al [v]). Furthermore, pharyngeal vowels like [ɑ ɒ] sometimes go with the velar vowels (cf. the continuous transition from "maximally velar" to "maximally pharyngeal" vowels), thus constituting a natural class which is unstatable unless one operates with back vowels. The issue is far from settled, however.

Distance: [dist] is a multivalued feature denoting distance from the most constricted pharyngeal vowel. As already mentioned, this feature together with the feature [back] defines two vowel dimensions (see fig. 1); each dimension is partitioned into five steps (i.e. [dist] is a pentavalent feature): [ɑ ɒ ⍺] are [1 dist], [æ Œ a ʌ] are [2 dist], [ɛ œ ɔ] are [3 dist], [e ø o] are [4 dist], and [i y u] are [5 dist]. [ɹ ʁ ʁ̥] are [1 dist], and all other consonants are [5 dist], except [h] which is unspecified for this feature. Our use of the feature [dist] recalls the traditional use of [height] (these features being "inverse proportional", of course). However, [height] is normally considered a "vertical" dimension, which is "perpendicular" on the dimension front-back, with the detrimental consequence that the distinction [a]:[ɑ] is, traditionally, seen purely as one of front:back and not of height. That it is justified to consider e.g. the vowels [i e ɛ æ ɑ] to "lie on the same line", not only physiologically and perceptually, but also phonologically, is shown by the principles of r-colouring which consists of, roughly speaking, decrease by one step in the dimension of [distance].

Aobligatoryshort: The use of the feature [aoblsh] is a "trick", as the name suggests. It is used as the only distinction between the vowels [a ⍺], which are [+aoblsh], and [æ ɑ], which are identical to [a ⍺], respectively, with the exception that [æ ɑ] are [-aoblsh]. All other segments are unspecified for this feature. The name is due to the fact that [a ⍺] only occur as short vowels (when the results of combined ə-assimilation and merger of /VV/ and /V:/ are disregarded, as in da en... [daen/daən/daan/da·n]).[1]

1) It may be easier to quantify the output of our grammar (e.g. by turning it into a suitable input to Peter Holtse's speech synthesis) if [aoblsh] is substituted e.g. by a feature "relatively distant", distinguishing [æ ⍺] (as [+rel dist]) from [a ɑ] (as [-rel dist]). This change would not affect the rest of our grammar. We have chosen to operate with the feature [aoblsh] since it uses the only obvious phonological difference between the "a-vowels". Phonetically, however, [aoblsh] is even more arbitrary than [rel dist] (which amounts to saying that the least distant unrounded vowels need to be further subdivided with respect to something like distance).

Tense: The feature [tense] distinguishes between full vowels, which are [+tense], and [ɩ ɨ ə], which are [-tense] (the tense counterparts of [ɩ ɨ ə] are [i e ɛ]). All consonants are considered unspecified for this feature.

Grave: [grave] is defined as an acoustic/auditory feature. For the inventory of segments used here, [grave] may be predicted from independent features: all segments which are [+back], as well as all labial consonants, are [+grave]; consequently, all front vowels, as well as all consonants which are neither back nor labial, are [-grave]. ([h] is unspecified for this feature.)

Long: Vowels may be [+long] or [-long], whereas all consonants are considered [-long].

2.2 Syllabicity

As mentioned in the previous section, the full vowels and [ə, ɩ, ɨ] are [+syllabic], whereas all phonetic consonants as well as [j w ɹ ð ɣ] are [-syllabic]. How do we then handle the "schwa-assimilation rules" which create so-called "syllabic consonants", e.g. in handel 'trade' [han?əl] (distinct pronunciation), which is most often pronounced without the vowel [ə], but nevertheless remains a bisyllabic word?

Our grammar contains an optional schwa-deletion rule which changes e.g. [ˇhan?ˇəlˇ] into [ˇhan?ˇlˇ]. Since [l] is the only segment of the second syllable (which is delineated by the two syllable boundaries ˇ), it must be "syllabic", i.e. constitute the peak of this (weak) syllable. This treatment of syllabicity is prosodic.

When [ə] is deleted in a word like kommer 'comes' [ˇkʌm?ˇəɹˇ], the result is [ˇkʌm?ˇɹˇ], i.e. [ɹ] is the peak of the second syllable. This analysis agrees well with the large variability of the syllabic [ˇɹˇ], which may cover the whole range of (unstressed) [ʌ/ɒ].

In a case like kasse 'box' [ˇkasˇəˇ], deletion of [ə] yields the result [ˇkasˇˇ] which suggests a bisyllabic word (where the two-peak-syllabicity may be manifested by length of [s] and by a special intonation). In many cases, at least, where an obstruent should carry the second peak, the bisyllabic word may be reduced to a monosyllable. We may thus operate with an optional rule which deletes a syllable boundary in cases where there is no sonorant adjacent to the deleted schwa.[1]

The syllabic structure thus established (in the notation) by means of the syllable boundaries, together with information on stress (which is not yet available in our grammar), can then be used for the quantification of F_o, intensity and duration which is necessary in the speech synthesis project.

2.3 The stød

We consider the stød to be a prosodic entity, characterizing a syllable with a full vowel as its peak, and indicated as a distinctive feature ([+stød]) of the syllabic peak. Thus only full vowels (which are always [+syllabic, -consonantal, +tense]) can have stød.

It is a consequence of this prosodic treatment of stød that an early stød-rule like "the root-syllable of a prefixed verb gets stød" will assign stød to the short full vowel of words like bekomme 'get', forkaste 'reject', although phonetically there is stød on [m] in the former word and no real stød at all in the latter (see below). It is another consequence of our stød-treatment that the optional vowel shortening rule before

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1) This formulation, which is meant as a very first approximation, is chosen because it permits syllable reduction regardless of the precise location of the boundary between the syllable from which schwa is deleted, and the preceding syllable. The rule might, for example, delete the former of the two syllable boundaries in the following sequences: ˇ[-son]ˇ, ˇ[-son][-son]ˇ, and [-son]ˇˇ (as general, the rule should not apply across the grammatical boundary /).

glides need not pay any attention to the location of the stød in a word like ud 'out' [u·?ð, uð?], since the stød will still be a distinctive feature of the vowel also after it has been shortened.

In UNITMATRIX the 16 qualitatively different full vowels occur four times each, viz. as [...., -stød, -long], [...., +stød, -long], [...., -stød, +long], and as [...., +stød, +long] (the order of the 16 vowels is identical in the four groups, each of which may be said to represent a "syllable type"). In the input to the grammar the four syllable types are represented as XVY, XV?Y, XV·Y, and XV·?Y, respectively (unless stød and/or quantity are assigned by rule), where V is a vowel and X and Y arbitrary sequences (including null) of units belonging to the same syllable (including its boundaries).

In the printout, the four syllable types are represented as XVY, XVZ(?)Y (see below), XV·Y, and XV·?Y, respectively. The second type is treated in different ways, according to the unit Z which occurs immediately after the short stød-vowel: if Z is a sonorant or a voiced continuant obstruent, the printout is XVZ?Y; if Z is a voiceless obstruent, or a voiced oral stop, or a boundary, the printout is XVZY, i.e. the stød sign ? is omitted. Thus, in cases like lyst, neuter 'clear (adj.)', or nyhed 'news' [lysd, nyhe·?ð], stød will be dropped in the printout as a consequence of the vowel shortening (of /y·/).

The procedure suggested here, viz. that stød is a characteristic of a syllable with a full vowel, and that it is considered a distinctive feature of the syllabic peak throughout the derivation (but not in the printout), permits the later quantification of F_o, intensity and duration to distinguish between e.g. flæsket as a noun in definite form and as an adjective, a distinction which is found in certain varieties of Standard Danish.

3. Some computational aspects of the project

3.1 Conversion into IPA-notation

As shown in fig. 1 in Basbøll/Kristensen 1974 (p. 218), the overall system was planned to include a subroutine which was to translate the input form in IPA-notation into a string of integers, and another subroutine which was to translate output from strings of integers into forms in IPA-notation. The purpose was to obtain an easy check of the correctness of the input and readability of the output, while internal integer representation of the phonological forms is desirable from a computational point of view. Now, the input form is nothing but a single string, the inventory of units occurring in input forms is only a fraction of all phonetic units, and, furthermore, the corresponding printout includes the input form. The translation can thus be done manually, as far as the input side is concerned (most symbols can be translated directly without recourse to a conversion table, because of the attempted similarity between the IPA-notation of a given input and its representation of characters as an input into the computer). The correspondence between the two character systems: IPA and the keyboard of the data terminal, is secured by a table-specified character conversion on the output side. This character conversion is accomplished in the punching of the output file. The resulting papertape is transferred to printout in IPA-notation by means of a papertape typewriter equipped with an IPA ball-head. (It should be remembered that the MAIN PROGRAM itself contains subroutines which translate the keyboard representation of a string into integer representation and back again.)

3.2 Description of a RUN

The rule testing program is run via a UNISCOPE 100 demand terminal. Using the ED processor, one may update RULEINDEX and RULEMATRIX and insert one or more input strings into a temporary file (the manual transformation from input in IPA-notation to the keyboard of the scope is quite simple, cf. above). The MAIN PROGRAM is stored in a permanent file in its symbolic form and in its absolute form. The program works on four types of data: 1) UNITMATRIX which is stored in the permanent file; 2) RULEINDEX and RULEMATRIX which, too, are stored in the permanent file; 3) rulelimits (see secion 3.4 below) are normally put in directly via the keyboard; 4) the input string(s) which may be stored in a temporary or permanent file[1] or put in directly.

Each RUN has two output files: 1) a file with printout consisting of RULEINDEX and RULEMATRIX which may be led to a line printer; 2) a punch tape file containing the input and output strings to and from the rules of the grammar, together with the designations H and L[2]. A printout of UNITMATRIX can be obtained

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1) At the moment, the data used for the phonotactic surveys of Jespersen 1926 and Vestergaard 1968 is stored in some file elements, which is expedient from the point of view of testing of rules (e.g. syllabification rules). We plan to store much more material of this kind. It is, for example, our intention to cover systematically all different /rV/-sequences as well as all different /VC/-sequences in which /V/ can be part of the relevant context for structural changes in /C/, and conversely.

2) In Basbøll/Kristensen 1974 (p. 225) we proposed to use the designations A (meaning "the obligatory rule was applied non-vacuously"), V (meaning "the rule was applied vacuously"), and O (meaning "application of the rule was tried, but its structural description was not satisfied"), in addition to L (meaning "the optional rule was applied non-vacuously") and H (meaning "non-application of an optional rule, the application of which would give rise to an L-form"). Since we no longer consider the information offered by the designations O and V phonologically important, we have omitted O and V. Furthermore, the information represented by an A is completely redundant in the printout since the rules which have been non-vacuously applied are listed, and if such a rule has no L-designation the rule must be obligatory, i.e. A. The only designations kept in the printout are, therefore, H and L (or, with the characters of the IPA ball-head, h and l), which saves considerable punching time and paper space.

after insertion of a couple of WRITE-statements into the MAIN PROGRAM. This seems inelegant, but updating of UNITMATRIX is rather rare.

The bipartition of the output from the data processing (cf. 1) and 2) above) is desirable because RULEINDEX and RULEMATRIX mainly consist of integers which the IPA ball-head does not contain, while the writing chain of the line printer does not contain the IPA-symbols. (Later on when updating of RULEINDEX and RULEMATRIX will not be necessary any more, the WRITE-statements causing these to be printed out can be omitted, and the system will be simpler.)

3.3 Optional rules

In Basbøll/Kristensen 1974, p. 223-224, it was described how the MAIN PROGRAM was to handle the facultativity which is implicated by the optional rules of the grammar: If the grammar contains n optional rules, each input form was to follow 2^n different paths of derivation. This method has now proved to be clearly uneconomic, for most often only a few of the optional rules are relevant to a given input string (as we realized, in fact, on p. 224!). In a test of a subcomponent of the grammar containing about 10 optional rules, the RUNtimes were found to be excessively long. A new structure of the MAIN PROGRAM was painfully necessary. Now a minimum of different paths of derivation are followed. First of all, the input string is taken through the grammar. Hereby the program tries to apply all the rules of the grammar, optional or not, to the output form from the preceding rule (or, in case, the input form to the grammar). Every time the input string satisfies the structural description of an optional rule and this input string is changed by the application of the rule (i.e. the application is non-vacuous), a node is established. When all the rules have been run through, and the output forms and the designations H and L have been transferred to the output file, the last established node is taken from the node list together with the number of the (optional) rule where the node was established. From this point of the grammar all L paths with respect to this rule have already been followed. The H paths with respect to this rule have the same derivational history as the L paths before the optional rule in question, and the different variables still contain the relevant output forms and designations. Now the program deletes the node in question and goes on to the next rule (without trying to apply the optional rule whose node has just been deleted), application of the remaining rules is tried, and maybe new nodes are established. This procedure is continued until the node list is empty. The method is economic because every time a new node is handled, the computer processes data already in existence, placing a new layer of data over data already written out. The gain from this revision of the MAIN PROGRAM is really considerable.

3.4 Rule limits

As hinted at in section 3.2, it is now possible for us to test arbitrary parts of the grammar. This is desirable from an economic point of view, because the RUNtime will be shortened (in particular when only obligatory rules are tested), and also because a lot of information which is irrelevant for the problem at hand can be avoided. The part of the grammar to be tested is selected by deciding the limits in terms of rule numbers for the block or blocks of rules which one wants to have included in the desired grammar. The limits ordered in sets of pairs of (rule) numbers are input to the data processing, as mentioned in section 3.2. Moreover, such sets of rule limits corresponding to different parts of the grammar (e.g. those rule limits defining the set of all obligatory rules, giving rise to the most distinct and conservative output form of each input form) may be stored in a permanent file and added as input in a single command.

```
input   ///indspʁø?jt///
i
   output fʁɑ ʁegel nʁ
   i          //ˇ/indspʁøj?t///
   v          //ˇ/indspʁøj?tˇ///
   xix        //ˇ/indˇspʁøj?tˇ///
   xxvii      //ˇ/endˇspʁøj?tˇ///
   xxix       //ˇ/enðˇspʁøj?tˇ///
   xxxi       //ˇ/enˇspʁøj?tˇ///
   xxxv       //ˇ/enˇspʁʌj?tˇ///
   lxi        //ˇ/enˇsbʁʌj?tˇ///
```

```
input   ///stegning///
i
   output fʁɑ ʁegel nʁ
   iii        //ˇ/stegning///
   v          //ˇ/stegningˇ///
   xiv        //ˇ/stegˇningˇ///
   xxii       //ˇ/stegˇniŋgˇ///
   xxvii      //ˇ/stegˇneŋgˇ///
   xxix       //ˇ/steɣˇneŋɣˇ///
   xxxii      //ˇ/steɣˇneŋˇ///
   xxxiv      //ˇ/stajˇneŋˇ///
   lxi        //ˇ/sdajˇneŋˇ///
```

```
input   ///ty?ngdə///
i
   output fʁɑ ʁegel nʁ
   ii         //ˇ/tyn?gdə///
   v          //ˇ/tyn?gdəˇ///
   xv         //ˇ/tyn?gˇdəˇ///
   xxii       //ˇ/tyŋ?gˇdəˇ///
   xxvii      //ˇ/tøŋ?gˇdəˇ///
   xxix       //ˇ/tøŋ?ɣˇdəˇ///
   xxxii      //ˇ/tøŋ?ˇdəˇ///
```

```
input   ///ʁɛdsɔ?m///
i
   output fʁɑ ʁegel nʁ
   ii         //ˇ/ʁɛdsɔm?///
   v          //ˇ/ʁɛdsɔm?ˇ///
   xiv        //ˇ/ʁɛdˇsɔm?ˇ///
   xxix       //ˇ/ʁɛðˇsɔm?ˇ///
   xxxix      //ˇ/ʁæðˇsɔm?ˇ///
   xliv       //ˇ/ʁæðˇsʌm?ˇ///
```

```
input   ///fængəhol///
i
   output fʁɑ ʁegel nʁ
   ii         //ˇ/fængəhol///
   v          //ˇ/fængəholˇ///
   viii       //ˇ/fængəˇholˇ///
   ix         //ˇ/fængˇəˇholˇ///
   xxii       //ˇ/fæŋgˇəˇholˇ///
   xxix       //ˇ/fæŋɣˇəˇholˇ///
   xxxii      //ˇ/fæŋˇəˇholˇ///
   xxxiii     //ˇ/faŋˇəˇholˇ///
   xlv        //ˇ/faŋˇəˇhɔlˇ///
   xlvi       //ˇ/fɤŋˇəˇhɔlˇ///
```

Figure 2

Derivations of the words _indsprøjt_, _stegning_, _tyngde_, _rædsom_, and _fangehul_. Only obligatory rules are applied, and each word has, therefore, only one version (see section 4).

```
input   ///kʁæ·ʔv///
i
   output fʁɑ ʁegel nʁ
   iii          //ˇ/kʁæ·ʔv///
   v            //ˇ/kʁæ·ʔvˇ///
   xxxviii      //ˇ/kʁɑ·ʔvˇ///
   lv           //ˇ/kʁɑ·ʔwˇ///
   lxxi         //ˇ/kʁɑwʔˇ///
   ʁegel        bem
   lv            l
   lxxi          l
ii
   output fʁɑ ʁegel nʁ
   iii          //ˇ/kʁæ·ʔv///
   v            //ˇ/kʁæ·ʔvˇ///
   xxxviii      //ˇ/kʁɑ·ʔvˇ///
   lv           //ˇ/kʁɑ·ʔwˇ///
   ʁegel        bem
   lv            l
   lxxi          h
iii
   output fʁɑ ʁegel nʁ
   iii          //ˇ/kʁæ·ʔv///
   v            //ˇ/kʁæ·ʔvˇ///
   xxxviii      //ˇ/kʁɑ·ʔvˇ///
   ʁegel        bem
   lv            h
input   ///flæ·ʔd///
i
   output fʁɑ ʁegel nʁ
   iii          //ˇ/flæ·ʔd///
   v            //ˇ/flæ·ʔdˇ///
   xxix         //ˇ/flæ·ʔðˇ///
   lxxi         //ˇ/flæðʔˇ///
   lxxii        //ˇ/flaðʔˇ///
   ʁegel        bem
   lxxi          l
   lxxii         l
ii
   output fʁɑ ʁegel nʁ
   iii          //ˇ/flæ·ʔd///
   v            //ˇ/flæ·ʔdˇ///
   xxix         //ˇ/flæ·ʔðˇ///
   lxxi         //ˇ/flæðʔˇ///
   ʁegel        bem
   lxxi          l
   lxxii         h
iii
   output fʁɑ ʁegel nʁ
   iii          //ˇ/flæ·ʔd///
   v            //ˇ/flæ·ʔdˇ///
   xxix         //ˇ/flæ·ʔðˇ///
   ʁegel        bem
   lxxi          h
```

Figure 3

Derivations of the words <u>krav</u> and <u>flad</u>. Both optional and obligatory rules are applied. Each word has three versions (see section 4).

```
input   ///kʁi·?g///
i
   output fʁa ʁegel nʁ
   iii          //ˇ/kʁi·?g///
   v            //ˇ/kʁi·?gˇ///
   xxix         //ˇ/kʁi·?ɣˇ///
   l            //ˇ/kʁi·?jˇ///
   lxviii       //ˇ/kʁi·?ˇ///
   ʁegel        bem
   l             l
   lxviii        l
ii
   output fʁa ʁegel nʁ
   iii          //ˇ/kʁi·?g///
   v            //ˇ/kʁi·?gˇ///
   xxix         //ˇ/kʁi·?ɣˇ///
   l            //ˇ/kʁi·?jˇ///
   lxxi         //ˇ/kʁij?ˇ///
   ʁegel        bem
   l             l
   lxviii        h
   lxxi          l
iii
   output fʁa ʁegel nʁ
   iii          //ˇ/kʁi·?g///
   v            //ˇ/kʁi·?gˇ///
   xxix         //ˇ/kʁi·?ɣˇ///
   l            //ˇ/kʁi·?jˇ///
   ʁegel        bem
   l             l
   lxviii        h
   lxxi          h
iv
   output fʁa ʁegel nʁ
   iii          //ˇ/kʁi·?g///
   v            //ˇ/kʁi·?gˇ///
   xxix         //ˇ/kʁi·?ɣˇ///
   lxviii       //ˇ/kʁi·?ˇ///
   ʁegel        bem
   l             h
   lxviii        l
v
   output fʁa ʁegel nʁ
   iii          //ˇ/kʁi·?g///
   v            //ˇ/kʁi·?gˇ///
   xxix         //ˇ/kʁi·?ɣˇ///
   lxxi         //ˇ/kʁiɣ?ˇ///
   ʁegel        bem
   l             h
   lxviii        h
   lxxi          l
vi
   output fʁa ʁegel nʁ
   iii          //ˇ/kʁi·?g///
   v            //ˇ/kʁi·?gˇ///
   xxix         //ˇ/kʁi·?ɣˇ///
   ʁegel        bem
   l             h
   lxviii        h
   lxxi          h
```

Figure 4

Derivations of the word <u>krig</u>. Both optional and obligatory rules are applied. The word has six versions (see section 4).

```
input   ///spʁing/u·?d//idio·?t///
i
    output  fʁɑ ʁegel nʁ
    i          ///spʁingˇ/u·?d/ˇ/idio·?t///
    iv         //ˇ/spʁingˇ/u·?d/ˇ/idio·?t///
    v          //ˇ/spʁingˇ/u·?d/ˇ/idio·?tˇ///
    vi         //ˇ/spʁingˇ/u·?d/ˇ/idiˇo·?tˇ///
    viii       //ˇ/spʁingˇ/u·?d/ˇ/iˇdiˇo·?tˇ///
    xxii       //ˇ/spʁiŋgˇ/u·?d/ˇ/iˇdiˇo·?tˇ///
    xxvii      //ˇ/spʁeŋgˇ/u·?d/ˇ/iˇdiˇo·?tˇ///
    xxix       //ˇ/spʁeŋɣˇ/u·?ð/ˇ/iˇdiˇo·?tˇ///
    xxxii      //ˇ/spʁeŋˇ/u·?ð/ˇ/iˇdiˇo·?tˇ///
    xliii      //ˇ/spʁɛŋˇ/u·?ð/ˇ/iˇdiˇo·?tˇ///
    lxi        //ˇ/sbʁɛŋˇ/u·?ð/ˇ/iˇdiˇo·?tˇ///
    lxvi       //ˇ/sbʁɛŋˇ/u·?ð/ˇ/iˇdiˇo·?dˇ///
    lxxi       //ˇ/sbʁɛŋˇ/uð?/ˇ/iˇdiˇo·?dˇ///
    ʁegel      bem
    xliii       l
    lxvi        l
    lxxi        l
ii
    output  fʁɑ ʁegel nʁ
    i          ///spʁingˇ/u·?d/ˇ/idio·?t///
    iv         //ˇ/spʁingˇ/u·?d/ˇ/idio·?t///
    v          //ˇ/spʁingˇ/u·?d/ˇ/idio·?tˇ///
    vi         //ˇ/spʁingˇ/u·?d/ˇ/idiˇo·?tˇ///
    viii       //ˇ/spʁingˇ/u·?d/ˇ/iˇdiˇo·?tˇ///
    xxii       //ˇ/spʁiŋgˇ/u·?d/ˇ/iˇdiˇo·?tˇ///
    xxvii      //ˇ/spʁeŋgˇ/u·?d/ˇ/iˇdiˇo·?tˇ///
    xxix       //ˇ/spʁeŋɣˇ/u·?ð/ˇ/iˇdiˇo·?tˇ///
    xxxii      //ˇ/spʁeŋˇ/u·?ð/ˇ/iˇdiˇo·?tˇ///
    xliii      //ˇ/spʁɛŋˇ/u·?ð/ˇ/iˇdiˇo·?tˇ///
    lxi        //ˇ/sbʁɛŋˇ/u·?ð/ˇ/iˇdiˇo·?tˇ///
    lxvi       //ˇ/sbʁɛŋˇ/u·?ð/ˇ/iˇdiˇo·?dˇ///
    ʁegel      bem
    xliii       l
    lxvi        l
    lxxi        h
iii
    output  fʁɑ ʁegel nʁ
    i          ///spʁingˇ/u·?d/ˇ/idio·?t///
    iv         //ˇ/spʁingˇ/u·?d/ˇ/idio·?t///
    v          //ˇ/spʁingˇ/u·?d/ˇ/idio·?tˇ///
    vi         //ˇ/spʁingˇ/u·?d/ˇ/idiˇo·?tˇ///
    viii       //ˇ/spʁingˇ/u·?d/ˇ/iˇdiˇo·?tˇ///
    xxii       //ˇ/spʁiŋgˇ/u·?d/ˇ/iˇdiˇo·?tˇ///
    xxvii      //ˇ/spʁeŋgˇ/u·?d/ˇ/iˇdiˇo·?tˇ///
    xxix       //ˇ/spʁeŋɣˇ/u·?ð/ˇ/iˇdiˇo·?tˇ///
    xxxii      //ˇ/spʁeŋˇ/u·?ð/ˇ/iˇdiˇo·?tˇ///
    xliii      //ˇ/spʁɛŋˇ/u·?ð/ˇ/iˇdiˇo·?tˇ///
    lxi        //ˇ/sbʁɛŋˇ/u·?ð/ˇ/iˇdiˇo·?tˇ///
    lxxi       //ˇ/sbʁɛŋˇ/uð?/ˇ/iˇdiˇo·?tˇ///
    ʁegel      bem
    xliii       l
    lxvi        h
    lxxi        l
iv
    output  fʁɑ ʁegel nʁ
    i          ///spʁingˇ/u·?d/ˇ/idio·?t///
    iv         //ˇ/spʁingˇ/u·?d/ˇ/idio·?t///
    v          //ˇ/spʁingˇ/u·?d/ˇ/idio·?tˇ///
    vi         //ˇ/spʁingˇ/u·?d/ˇ/idiˇo·?tˇ///
    viii       //ˇ/spʁingˇ/u·?d/ˇ/iˇdiˇo·?tˇ///
    xxii       //ˇ/spʁiŋgˇ/u·?d/ˇ/iˇdiˇo·?tˇ///
    xxvii      //ˇ/spʁeŋgˇ/u·?d/ˇ/iˇdiˇo·?tˇ///
    xxix       //ˇ/spʁeŋɣˇ/u·?ð/ˇ/iˇdiˇo·?tˇ///
    xxxii      //ˇ/spʁeŋˇ/u·?ð/ˇ/iˇdiˇo·?tˇ///
    xliii      //ˇ/spʁɛŋˇ/u·?ð/ˇ/iˇdiˇo·?tˇ///
    lxi        //ˇ/sbʁɛŋˇ/u·?ð/ˇ/iˇdiˇo·?tˇ///
    ʁegel      bem
    xliii       l
    lxvi        h
    lxxi        h
```

Figure 5 (part 1)

v

output fʁɑ ʁegel nʁ	
i	///spʁingˇ/u·ʔd/ˇ/idio·ʔt///
iv	//ˇ/spʁingˇ/u·ʔd/ˇ/idio·ʔt///
v	//ˇ/spʁingˇ/u·ʔd/ˇ/idio·ʔtˇ///
vi	//ˇ/spʁingˇ/u·ʔd/ˇ/idiˇo·ʔtˇ///
viii	//ˇ/spʁingˇ/u·ʔd/ˇ/iˇdiˇo·ʔtˇ///
xxii	//ˇ/spʁiŋgˇ/u·ʔd/ˇ/iˇdiˇo·ʔtˇ///
xxvii	//ˇ/spʁeŋgˇ/u·ʔd/ˇ/iˇdiˇo·ʔtˇ///
xxix	//ˇ/spʁeŋɣˇ/u·ʔð/ˇ/iˇdiˇo·ʔtˇ///
xxxii	//ˇ/spʁeŋˇ/u·ʔð/ˇ/iˇdiˇo·ʔtˇ///
lxi	//ˇ/sbʁeŋˇ/u·ʔð/ˇ/iˇdiˇo·ʔtˇ///
lxvi	//ˇ/sbʁeŋˇ/u·ʔð/ˇ/iˇdiˇo·ʔdˇ///
lxxi	//ˇ/sbʁeŋˇ/uðʔ/ˇ/iˇdiˇo·ʔdˇ///
ʁegel	bem
xliii	h
lxvi	l
lxxi	l

vi

output fʁɑ ʁegel nʁ	
i	///spʁingˇ/u·ʔd/ˇ/idio·ʔt///
iv	//ˇ/spʁingˇ/u·ʔd/ˇ/idio·ʔt///
v	//ˇ/spʁingˇ/u·ʔd/ˇ/idio·ʔtˇ///
vi	//ˇ/spʁingˇ/u·ʔd/ˇ/idiˇo·ʔtˇ///
viii	//ˇ/spʁingˇ/u·ʔd/ˇ/iˇdiˇo·ʔtˇ///
xxii	//ˇ/spʁiŋgˇ/u·ʔd/ˇ/iˇdiˇo·ʔtˇ///
xxvii	//ˇ/spʁeŋgˇ/u·ʔd/ˇ/iˇdiˇo·ʔtˇ///
xxix	//ˇ/spʁeŋɣˇ/u·ʔð/ˇ/iˇdiˇo·ʔtˇ///
xxxii	//ˇ/spʁeŋˇ/u·ʔð/ˇ/iˇdiˇo·ʔtˇ///
lxi	//ˇ/sbʁeŋˇ/u·ʔð/ˇ/iˇdiˇo·ʔtˇ///
lxvi	//ˇ/sbʁeŋˇ/u·ʔð/ˇ/iˇdiˇo·ʔdˇ///
ʁegel	bem
xliii	h
lxvi	l
lxxi	h

vii

output fʁɑ ʁegel nʁ	
i	///spʁingˇ/u·ʔd/ˇ/idio·ʔt///
iv	//ˇ/spʁingˇ/u·ʔd/ˇ/idio·ʔt///
v	//ˇ/spʁingˇ/u·ʔd/ˇ/idio·ʔtˇ///
vi	//ˇ/spʁingˇ/u·ʔd/ˇ/idiˇo·ʔtˇ///
viii	//ˇ/spʁingˇ/u·ʔd/ˇ/iˇdiˇo·ʔtˇ///
xxii	//ˇ/spʁiŋgˇ/u·ʔd/ˇ/iˇdiˇo·ʔtˇ///
xxvii	//ˇ/spʁeŋgˇ/u·ʔd/ˇ/iˇdiˇo·ʔtˇ///
xxix	//ˇ/spʁeŋɣˇ/u·ʔð/ˇ/iˇdiˇo·ʔtˇ///
xxxii	//ˇ/spʁeŋˇ/u·ʔð/ˇ/iˇdiˇo·ʔtˇ///
lxi	//ˇ/sbʁeŋˇ/u·ʔð/ˇ/iˇdiˇo·ʔtˇ///
lxxi	//ˇ/sbʁeŋˇ/uðʔ/ˇ/iˇdiˇo·ʔtˇ///
ʁegel	bem
xliii	h
lxvi	h
lxxi	l

viii

output fʁɑ ʁegel nʁ	
i	///spʁingˇ/u·ʔd/ˇ/idio·ʔt///
iv	//ˇ/spʁingˇ/u·ʔd/ˇ/idio·ʔt///
v	//ˇ/spʁingˇ/u·ʔd/ˇ/idio·ʔtˇ///
vi	//ˇ/spʁingˇ/u·ʔd/ˇ/idiˇo·ʔtˇ///
viii	//ˇ/spʁingˇ/u·ʔd/ˇ/iˇdiˇo·ʔtˇ///
xxii	//ˇ/spʁiŋgˇ/u·ʔd/ˇ/iˇdiˇo·ʔtˇ///
xxvii	//ˇ/spʁeŋgˇ/u·ʔd/ˇ/iˇdiˇo·ʔtˇ///
xxix	//ˇ/spʁeŋɣˇ/u·ʔð/ˇ/iˇdiˇo·ʔtˇ///
xxxii	//ˇ/spʁeŋˇ/u·ʔð/ˇ/iˇdiˇo·ʔtˇ///
lxi	//ˇ/sbʁeŋˇ/u·ʔð/ˇ/iˇdiˇo·ʔtˇ///
ʁegel	bem
xliii	h
lxvi	h
lxxi	h

Figure 5 (part 2)

Derivations of the utterance Spring ud, idiot! Both optional and obligatory rules are applied. The utterance has eight versions (see section 4).

4. Examples of derivations

Before we conclude this report (in section 5) by stating some areas which our project might be enlargened to cover, we shall refer the reader to fig.s 2-5 which contain examples of derivations within the present version of our grammar.

Fig. 2 contains derivations of the words indsprøjt 'inject', stegning 'roasting',[1] tyngde 'heaviness', rædsom 'horrible', and fangehul 'dungeon'; only the obligatory rules are applied, and the output should thus be distinct, conservative pronunciations (but only in cases where alternative pronunciations exist, of course).

Fig. 3 contains derivations of the words krav 'demand' and flad 'flat', where all rules, including the optional ones, are included in the testing. Each word has three different versions.

Fig. 4 contains derivations of the word krig 'war', all rules being included in the testing. The two outputs [kʁi·?] are both included in the printout since they have different derivational histories (corresponding to the phonological fact that the final non-syllabic segment may be dropped after high vowels, both in standards with [ɣ] as a separate segment, and in younger standards where [ɣ] has been replaced by [j, w]).

Fig. 5 contains the derivations of the utterance spring ud, idiot! 'jump, (you) idiot!'. There are eight versions of this utterance, corresponding to the optionality of r-colouring of e,

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1) We have used the orthographic form /stegning/ as input, in agreement with section 5 (ii) below, although the full vowel /i/ ought, from a purely phonological point of view, to be substituted by the lax vowel /ə/ (see section 2 above). In that case, the derivation of the second syllable would have passed through the derivational stages nəŋg , nɩŋg (by vowel raising of schwa before velars), and nɨŋg (by lowering of high front vowels before nasals).

of vowel shortening before ð, and of de-aspiration of an utterance-final plosive (notice that these phenomena are independent of each other, in contradistinction to the optional rules applied to krav, flad in fig. 3).

5. Further work

There are several directions into which we may continue our project. Three of these will be mentioned below (there are several others, e.g. concerning an automatic determination of the redundancy of UNITMATRIX, which will not be discussed here).

(i) We try to make the phonetic output of our rules so specific, detailed, and phonetically realistic that it can be used as input to Peter Holtse's project of speech synthesis by rule of Standard Danish. One aspect of this coordination is the attempt to use a phonetically satisfying distinctive feature analysis of our units, although it may sometimes seem too redundant and unelegant from an abstract phonological point of view (cf. section 2.1 above). Our cooperation with Peter Holtse is planned to continue.

(ii) Concerning the more abstract parts of our grammar, we try to approach the possibility of using orthographic forms as input to our rule system (as can be seen from the examples of derivations in fig.s 2-5, our input forms are at present mostly very close to orthographic forms, the main deviation being that we need, so far, more information than the writing gives as to stød and the distinction of schwa vs. the full vowel /e/ the standard writing provides us with). Our attempt to use orthographic or near-orthographic forms as input to the greatest possible extent,[1] is justified for at least two reasons: firstly, the input will be well-defined and not "open-ended", cf. the great difficulties in giving a non-arbitrary characterization of the systematic phonemic representations in generative phonology; and, secondly, we may be able to change writing into speech (by including the work suggested under (i) above), which opens up wide perspectives of practical use.

(iii) The third main line of our project is one of using the grammar we have constructed to investigate the notion of variable (or optional) rules, e.g. as to their possible interrelationship in a hierarchical (or other) structure. Thus the output forms of our grammar may be spoken by a person on tape (or, according to (i) above, may be realized by means of speech synthesis), and then evaluated by a number of informants as to acceptability, stylistic value, etc. Such an investigation might shed light on important issues in synchronic grammar, concerning the real nature of speech variation and variable rules.

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1) It is very simple to change the input to the grammar into "quasi-orthographic forms" by means of "rewrite-rules", viz. rules which double a single consonant between a short vowel and schwa, omit ?, rewrite ɛ, æ, ə, ɔ as æ, a, e and aa, etc. Such a quasi-orthographic notation immediately reveals the points where there is a non-superficial discrepancy between standard writing and our phonological forms. This might be of use in dealing with orthographical issues, since one may thereby find cases in which orthography could be made more regular (there are, of course, other kinds of information, such as spelling errors, which are more important in that context).

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STATISTIC RESEARCH ON CHANGES IN SPEECH DUE TO PEDAGOGIC TREATMENT (THE ACCENT METHOD)

Svend Smith[1] and Kirsten Thyme[2]

1. Introduction

The accent-method is a pedagogic method for improving speech and language.

It has come to its final shape through practical work and theoretical study within the last 40 years.

Physiologically it aims at introducing elasticity in the speech function.

By means of rhythmic exercises based on active contraction of abdominal muscles and consisting of accentuated and non-accentuated vocalization, the vibratory pattern of the vocal cords is being changed, so as to produce stronger harmonics.

The filtering process of the vocal tract is improved presumably as a result of a longer duration of the vocal cord contact within one single period and a higher flow through the glottis in the opening phase, which together counteracts the damping effect of the resonances in the vocal tract.

The acoustic effect of treatment along this line has been studied to some extent by different persons, as mentioned in this paper.

The accent method implies a linguistic approach which has been tried out in practice for several years and will be commented on in future papers.

The method has been used in the treatment of insufficient voices and blurred articulation as well as for pure pathological cases (pareses of vocal muscles). It is also part of the treatment of other speech defects, primarily stuttering and cluttering.

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2) Jonstrup Teachers' College

The present paper deals with some analyses of changes in timbre and intensity resulting from short-time treatment of insufficient voices according to the method mentioned above.

The background was the following: 80 persons received voice training in groups of 10. They received 10 consecutive lessons. This material constituted our first material for research.

Recordings of voices, before and after treatment, were carried out under identical circumstances. Students eventually listened to the 80 cases mentioned and delivered a written description of their impression of improvement or non-improvement.

30% of the patients (i.e. 24 cases) were found to exhibit some improvement. The information derived from this listening test showed 20 cases of stronger voice and 16 cases of higher intelligibility (i.e. 65% and 80%, respectively). This subjective result led us to a new plan of objective investigation, see section 2 below.

Former acoustic research on the effect of the accent method on pathological voices (B. Frøkjær-Jensen, K. Lauritzen and Svend Smith) pointed to the F2 region (above some 1000 Hz) as being the one which was characteristically developed. Several colleagues, on the other hand, had the impression that the development of voice as treated by means of the accent method first took place in a deeper formant region, the F2 region being one which did not develop until a development of "fullness" (roundness) had taken place. This would mean that harmonics below 1000 Hz (primarily F1) are first enhanced.[1]

The present investigation has been carried through exclusively by means of quantitative methods. The intensity has been investigated, and we have taken a special interest in trying to figure out whether certain time-factors (duration) have changed.

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1) Also cf. the paper by Børge Frøkjær-Jensen and Svend Prytz in this volume, in which they propose a new method which should demonstrate intensity relations in the higher and lower parts of the speech spectrum.

2. Material and method

Additional 220 students at a teachers' college (Jonstrup) were treated in the above mentioned way, i.e., they were subject to a treatment of a very short duration.

All voices were recorded before and after this short-time treatment.

A random choice of 30 now became our material of research. Care had been taken that all recordings of voices before and after treatment were carried out under identical circumstances, i.e. in the same room, and with the same recording machine, recording level, and microphone.[1] A short sentence in the middle of the story used for all recordings was chosen for the analysis: "Den ene efter den anden prøvede på at få ham til at forstå, at han ikke ville få lov til at forlade retten, før han havde betalt et pund."

The recordings of "before" and "after" were all recorded on a mingograph within one research session in order to avoid deviating settings of the gain controls of the various instruments used for the analysis. 7 channels on the mingograph were used (see fig. 1).

The curves were digitalized by means of a semi-automatic curve follower attached to a computer (IBM 1800). On the basis of these numbers stored in the computer, factors of duration and intensity were dealt with.

2.1. Durational investigation

The factors investigated were:

(D_i) The duration of the whole sentence before and after treatment.

(D_{ii}) The total duration of the fundamental (vocal cord vibrations) within the sentence. Band-pass filtering around the F_o-region.

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1) The microphone distance was measured out to be within the range 70-80 cm for all recordings, "before" and "after".

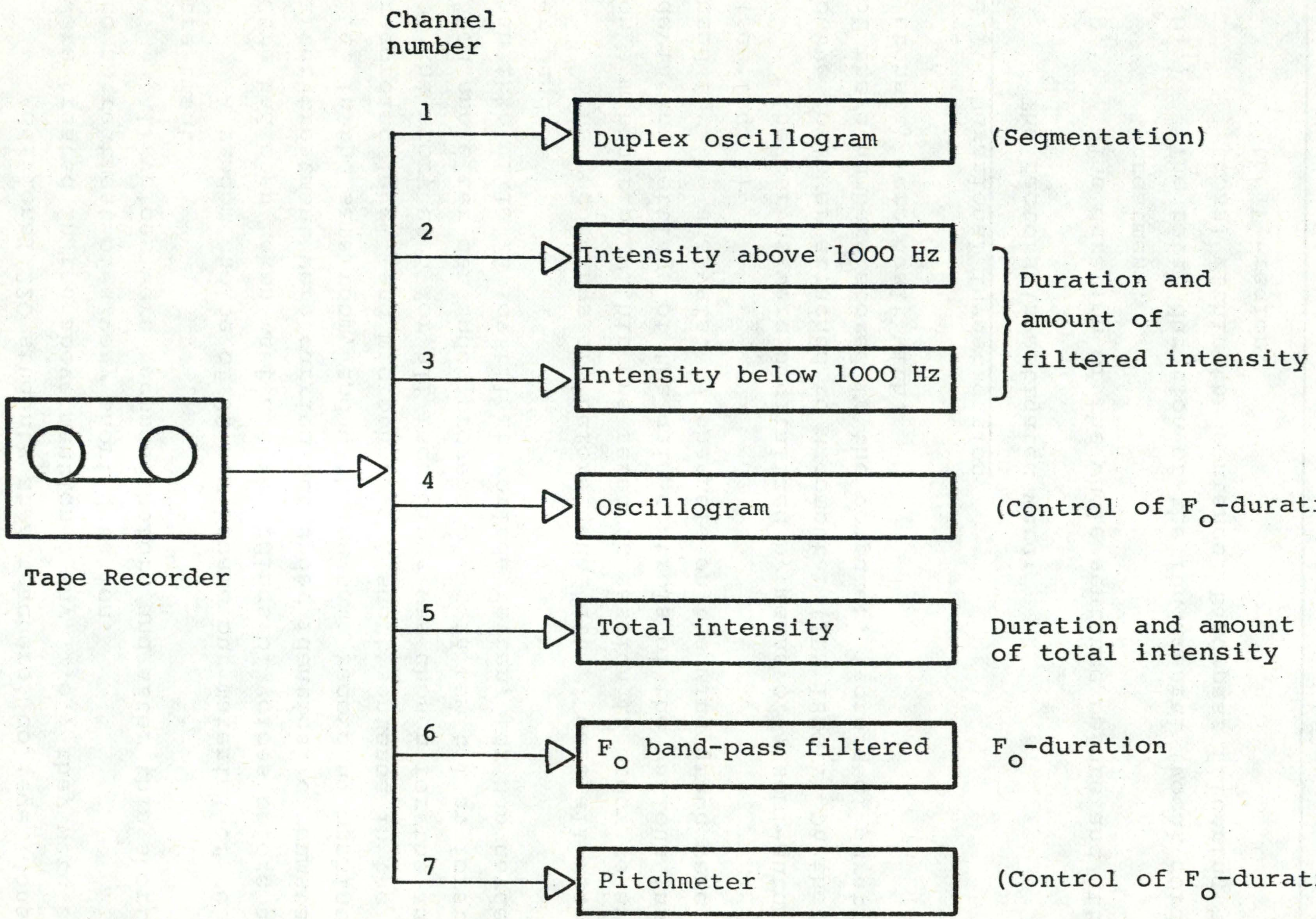

Figure 1

Schematic drawing contents of mingograph channels and the parameters that were measured from the different channels.

(D_{iii}) The total duration of intensity above 1000 Hz. High-pass filtering.

(D_{iv}) The total duration of intensity below 1000 Hz. Low-pass filtering.

2.2. Intensity investigation

The factors investigated were:

(I_i) The mean intensity in the total frequency range.

(I_{ii}) The mean intensity above 1000 Hz.

(I_{iii}) The mean intensity below 1000 Hz.

In order to be able to decide on the statistic significance of results to be expected, the Wilcoxon rank sum test for matched pairs was used.

The level of significance was fixed in advance (95%).

3. Results

3.1. Duration

see figs. 2 and 3.

(D_i) No statistically significant change was found with regard to the length of the whole sentence. The length of pauses was left out of consideration.

(D_{ii}) Likewise, the duration below 1000 Hz showed no statistically significant change, presumably on account of the exclusion from measurement of signals that were more than 40 dB below the maximum reference level.

(D_{iii}) However, above 1000 Hz (corresponding to the F2 and F3 region of vowels and the high frequency consonants), a 6% augmentation in length was found ($p \lesssim 0.003$) after treatment.

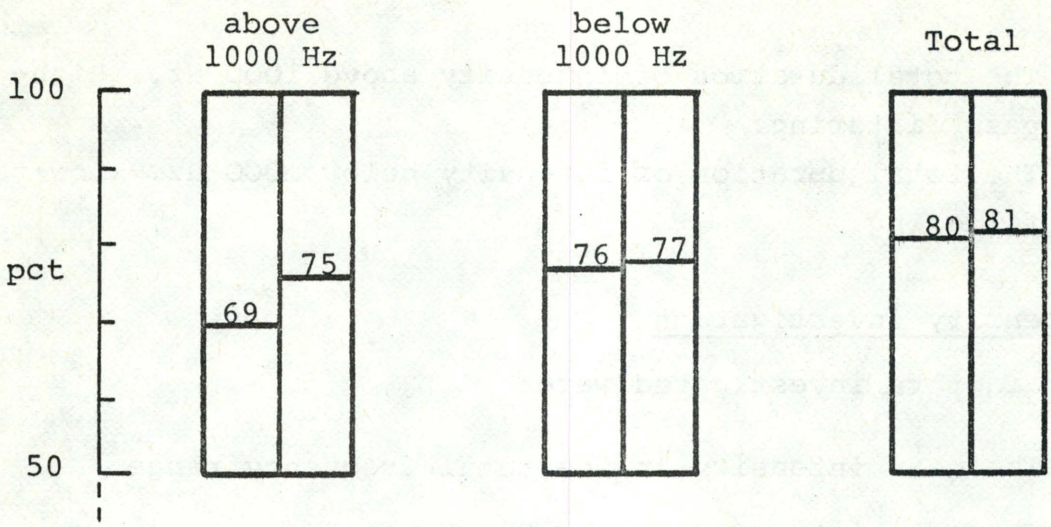

Figure 2

Duration of phonatory intensity in different frequency regions. Left columns show percentage intensity before treatment. Right columns show percentage intensity after treatment.

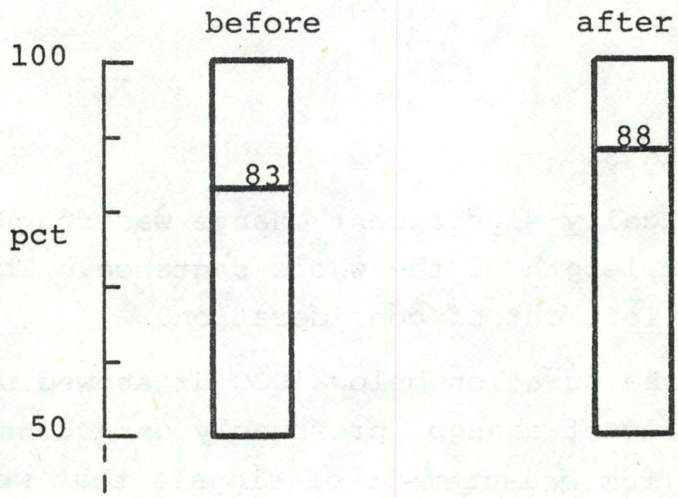

Figure 3

Duration of F_o shown as percentage of total utterance duration before and after treatment.

(D_{iv}) Even if the duration of the whole sentence did not change statistically, the duration of the fundamental was augmented by 5%, this result being statistically highly significant ($p \lesssim 0.001$). This change demonstrates an improved mobility of the vocal cords. Duration of phonatory intensity (D_{ii} above) cannot be compared to the measurement of duration of F_o, which is based on an observation of F_o (sinewave) on the band-pass curve.

3.2. Intensity

(I_i) The intensity within the whole frequency spectrum was augmented (+1.4 dB). The change was significant ($p. \lesssim 0.007$).

(I_{ii}) Below 1000 Hz the change was +1.6 dB, i.e. likewise significant ($p. \lesssim 0.007$).

(I_{iii}) A change in the intensity above 1000 Hz was, on the other hand, just significant ($p. \lesssim 0.04$).

4. Discussion and conclusion

A short-time treatment results in a greater amount of acoustic information transmitted to the environments. This information may involve:

(i) Increased duration of the fundamental.

(ii) Increased duration of sounds characterized by energy above 1000 Hz, so that these are more easily distinguishable (u, y, i - o, ø, e and high frequency consonants).

(iii) An increase of intensity below 1000 Hz (primarily the F1 region).

The latter result is interesting on account of the objective proof of a hypothesis which was formerly expressed on the basis of subjective judgments.

The higher energy below 1000 Hz would be expected to contribute to an improvement in intelligibility (information on the degree of openness in vowels), and to convey the impression of a fuller voice. To which degree a stronger fundamental adds to the fullness of the voice is not as yet clear.

Likewise it is possible that a smoother pitch curve results from short-time treatment.

A gross impression of spectrographic recordings (cross-sections) supports the above results, viz. that even a short-time treatment will

(iv) improve the mobility of the vocal cords,

(v) make the timbre rounder and to some extent more "light-coloured",

(vi) result in a stronger voice, and

(vii) enhance factors that are important for a higher intelligibility without slowing down the speed of articulation.

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