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Symposium No. 1

Phonetic Universals in Phonological Systems and their Explanation

PHONETIC UNIVERSALS IN PHONOLOGICAL SYSTEMS AND THEIR EXPLANATION

Summary of Moderator's Introduction

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In many ways the study of phonetic and phonological universals is a relatively old endeavor in linguistics and in other ways it is relatively new. It is old in the sense that some 100 years ago when our intellectual forefathers, Ellis, Sweet, Bell, Lepsius, Passy, Jespersen, and others were struggling to develop a workable phonetic alphabet that could be used to transcribe the sounds of any language, they had, implicitly at least, to deal with the problem of whether there were phonetic universals. That they succeeded in devising such a practical universally-applicable phonetic notation, such as we use today, is a tribute to their hard work, their vast experience with languages of the world, and their scientific judgment. The phonetic alphabet and the set of descriptive terms accompanying it are not perfect, of course, but modern work on universal sound patterns would be impossible without these important tools.

It is an old interest, too, in the sense that during the past century there has been a steady, if small, flow of relatively sophisticated explanations for observed universal sound patterns, e.g., (to mention just a few) Passy 1890, Issatchenko 1937, Troubetzkoy 1939, Jakobson 1941, Hockett 1955, Martinet 1955. Characteristic of the keen insights offered during this period are the following (and here I present remarks relevant to topics of particular interest to this symposium):

> Passy (1890) on obstruent devoicing: 'On remarque que ce sont les explosives qui se dévocalisent le plus souvent. Cela se conçoit, car pour produire une explosive vocalique, il faut chasser dans une chambre fermée l'air qui fait vibrer les cordes vocales; action qui nécessite un effort considérable, et ne peut pas se prolonger. Aussi les explosives doubles sont-elles particulièrement sujettes à devenir soufflées..' [161].

> Chao (1936) on the patterning of voiced glottalized stops: 'A very significant circumstance about the occurrence of [ʔb, ʔd, ɓ, ɗ] is that in all the [Chinese] dialects in which they are known to exist they are always limited to labials and dentals and never exist in velars ... The reason is not

far to seek. Between the velum and the glottis, there is not much room to do any of the tricks that can be done with the larger cavity for a b or a d. As soon as there is any vibration of the vocal cords, the cavity for a g is filled and a positive pressure is created. There is therefore no space or time to make any impression of suspension [of voici via simultaneous glottal closure, as with ?b and ?d] or of inward "explosion" as with [ɓ, ɗ]. The velar plosive is dif ficult to voice without having to do any additional tricks.'

In another sense, however, interest in universal sound patterns is rather recent or at least renewed. This has come about, I think, due to the interaction of a number of trends and events. First, there is the interest in phonological universals stimulate by the new set of research goals presented by generative phonolog namely, to look at universals of language for what they will reve about humans' genetically-based capacity for language.

Second, there has been the sheer accumulation of reliable phonological data on a large number of languages. Works such as Guthrie's Comparative Bantu and Li's Comparative Tai (to mention just two), which synthesize large amounts of phonological data, exemplify this trend. It is because of this latter development that a project such as the Stanford Phonology Archive, constructed by Charles Ferguson and Joseph Greenberg, was possible. Third, there has been the almost explosive growth of experimental phoneti over the past 30 years or so -- especially in the development of empirically-validated mathematical models of various aspects of the speech production and perception mechanisms. In short, phonologists have realized that the study of universal sound patterns can be interesting and very important and that they now have the resources to do a better job of it than ever before.

The contributions to this symposium on phonetic universals represent very well the wide range of data, of talents, and of theoretical outlooks that are necessary in this area.

Björn Lindblom, in 'Some phonetic null hypotheses for a biological theory of language' raises the possibility that the form of language and the range over which it varies when it changes, may be determined by the biological constraints of its human users. He looks to phonetics to provide the evidence on this issue.

Kenneth N. Stevens, in 'Bases for phonetic universals in the properties of the speech production and perception systems' considers how the natural classes among speech sounds must arise due to the individual members of the classes sharing common modes of production at the neuromuscular level and/or giving rise to a common set of sensory images via the tactile, kinesthetic, or auditory channels.

Kenneth Pike, in 'Universals and phonetic hierarchy' suggests that the inability of phonologists to integrate such elusive units as the syllable or stress group into their descriptions of language may be due to their commitment to use just a single hierarchical structure. He proposes the use of parallel but interlocking hierarchies, e.g., one each for the phonological, grammatical, and referential domains.

Two papers in this symposium and one section paper deal with closely related topics on universal patterns in languages' obstruent inventories.

Thomas V. Gamkrelidze, in 'Hierarchical relations among phonetic units as phonological universals', presents a comprehensive analysis of universal co-occurrence tendencies among various features of obstruents, e.g., place of articulation, voicing, glottalization, and uses this to support a reanalysis of the Indo-european stop inventory.

André G. Haudricourt, in 'Apparition et disparition des occlusives sonores préglottalisées', presents the phonetic factors that lead to the development or loss of voiced preglottalized stops and presents extensive supporting cross-linguistic data, especially from South and Southeast Asian languages.

Sandra Pinkerton, in her section paper 'Quichean (Mayan) glottalized and non-glottalized stops: a phonetic study with implications for phonological universals', presents instrumental data on the manner of production of glottalized stops in five Mayan languages. Having found voiceless uvular implosives, she proposes a revision of Greenberg's (1970) implicational hierarchy for glottalized stops which would equate it to Gamkrelidze's claims: voicing is marked for velar obstruents, voicelessness for labial obstruents.

Robert K. Herbert, in 'Typological universals, aspiration, and post-nasal stops', points out several universal patterns characteristic of nasal + stop clusters and uses these to call into question one reconstruction of the history of such clusters in Eastern Bantu languages.

Jean Marie Hombert, in 'Universals of vowel systems: the case of centralized vowels', presents data from speech perception tests conducted in the field with speakers of Fe?fe? (a Bantu language of Cameroon) which suggest that the universal tendency of disfavoring central vowels may have its origin in a human auditory constraint.

In my own paper, 'Universals of labial velars and de Saussure chess analogy', I present four phonetically-based universal patterns characteristic of labial velars and use this to call into question the wisdom of structuralist phonology's pre-occupation with system-internal relations in language and their descriptions.

Conclusion

It is worth mentioning that study of phonological universals is of more than theoretical interest. If it is done well, it coul yield results of great practical benefit, too, e.g., in such areas as speech therapy, second language teaching, speech recognition, and neurophysiology.

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UNIVERSALS OF LABIAL VELARS AND DE SAUSSURE'S CHESS ANALOGY

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In the Cours de linguistique generale de Saussure compares language to a chess game and the units of the linguistic code to the individual chess pieces. He remarks that

> If I use ivory chessmen instead of wooden ones, the change has no effect on the system ... The respective value of the pieces depends on their position on the chessboard just as each linguistic term derives its value from its opposition to all the other terms ... [A single] move has a repercussion on the whole system [1916 (1966:22; 88-89)].

The choice of the chess analogy was a brilliant piece of exposition. Justifiably, it is frequently cited, especially by teachers in linguistic courses, and has become one of the favorite images of the structuralist basis of linguistic analysis.

The structuralist approach in phonology means analyzing a given problem by taking the whole phonological system into consideration, e.g. all the phonemic oppositions, especially those which are symmetrical or asymmetrical, the functional load of the sounds involved, etc. It focuses, therefore, on system-internal relations between the 'pieces', i.e., the speech sounds. For example, the structuralist account of the introduction of [ʒ] into English would point out that it filled what was up to that time a gap in the English fricative system:

f	θ	s	ʃ
v	ð	z	◌

Generative phonology, a recent offshoot of structural linguistics, also focuses on system-internal relations between the 'pieces' although in this case the pieces are the rules of grammar and the entities which make up the lexicon.

In fact, almost any post-Saussurean "school" of phonology one might cite, e.g., the Prague school, glossematics, functional phonology, natural generative phonology, etc. -- all have adopted the structuralist method of looking within the system for the solution to their problems. Occasional explorations outside the system -- into anatomy, physiology, physics, psychology, etc. have never been pursued seriously or intently.[1]

I would maintain that this emphasis on system-internal relations in phonology is counter-productive. This point is especially evident when we examine and seek explanations for phonological universals. We frequently find speech sounds behaving in very similar ways across languages even though those languages exhibit remarkably varied structure. The phonological behavior of labial velars, i.e., [u, w, ʍ, k͡p, g͡b] etc. illustrates this rather dramatically.[2]

It has been claimed by generative phonologists that labial velars, although possessing two more or less equal constrictions, labial and velar, nevertheless, must be represented at the underlying (lexical) level as having only one primary articulation -- the other constriction being relegated to a secondary articulation (Chomsky and Halle 1968, Anderson 1976). The phonological behavior of a segment is supposedly a function of its underlying representation, not its surface phonetic character. Thus Anderson, in reviewing a number of West African languages, argues that Temne which has a /k/ but no /g/, must classify its /g͡b/ as a velar, filling the gap in the voiced velar stop position. Similarly he argues that since Nkonya has both /k/ and /k^w/, the second sound thus preempting the classification: 'primary articulation: velar; secondary articulation: labial', the sound /k͡p/ in that language must be primarily a labial with a secondary velar articulation. Efik, he notes, not only has a /k/ vs. /k^w/ contrast but also lacks a /p/, so it has two reasons for classifying its /k͡p/ as a labial.

One of the problems with such structural or functional accounts of phonological facts is that they attach undue significance to sound patterns which may commonly arise due to chance or at least due to factors unrelated to the particular phenomena under investigation. Attention to phonological universals would be some insurance against this problem. As it happens, /p/ and /g/ are often missing from languages' stop inventories (Gamkrelidze 1975, Sherman

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(1) Notable exceptions, however, are the fields of sociology, cultural history, and anthropology, which have been pursued seriously by many phonologists with structuralist orientation.

(2) The research on labial velars was done in collaboration with James Lorentz and published in Ohala and Lorentz (1977). Limitations of space prevent extensive documentation of the sound patterns discussed; however, the article cited may be consulted for numerous cross-linguistic examples.

1975). Moreover, there are many languages in West Africa that have /k͡p/ and/or /g͡b/ (Ladefoged 1964). Why therefore assume there is a special relationship between these two patterns in those few languages in which they both appear? A very preliminary statistical analysis of the co-occurrence of these patterns by Ohala and Lorentz (1977) found no disproportionate incidence of labial velar stops in languages which also have gaps in their stop inventory.

The most serious problem with such structuralist arguments, however, is that they often as not conflict with the evidence one can obtain from phonological alternations, including allophonic variation:

1) In spite of the double motivation mentioned above for assigning the Efik /k͡p/ to the labial slot (as well as an additional reason, cited by Welmers 1973, namely, that /k͡p/ sometimes is realized as the allophone [p]), Cook (1969) reports that a nasal assimilating to it sometimes appears as the velar nasal [ŋ].
2) According to Bearth (1971:18), Toura has both /k/ vs. /kʷ/ and /g/ vs. /gʷ/ contrasts, which, following the logic presented above, would force us to characterize /k͡p/ and /g͡b/ as labials. Nevertheless, these latter two sounds can be realized as [ŋk͡p] and [ŋg͡b], respectively, before nasal vowels.

Maybe one could still salvage the practice of looking only to system-internal relations in phonological analysis by abandoning the 'fill-the-gap' criteria and relying more heavily on how segments pattern in phonological rules. Unfortunately this escape route is not open either because labial velars can pattern in seemingly inconsistent ways in phonological rules.

3) The Yoruba labial velar glide /w/ (along with the labial velar stops /k͡p/ and /g͡b/) patterns with the labials /b, f, m/ in that it causes the merger of following /ã/ with /ɔ̃/; nevertheless, the nasal assimilating to /w/ shows up as the velar [ŋ] (Ward 1952).
4) In Kuwaa (Belleh), word initial /w/ is occasionally realized as [ŋʷ], i.e. a labialized velar nasal, but may become labial [v] before unrounded vowels (Thompson 1976).
5) In Tenango Otomi /h/ becomes labial fricative [ɸ] before /w/ but /n/ assimilating to /w/ appears as [ŋ] (Blight and Pike 1976).

Additional such cases are not difficult to find (Ohala and Lorentz 1977).

The seeming confusion of these patterns is cleared up when system-external evidence is obtained, viz., data on phonological universals and the physical phonetic causes of the universals. I offer the following four statements of universal tendencies to account for the observed data:

A. When affecting the quality of adjacent vowels, labial velars behave primarily as <u>labials</u>. (Specifically, they cause vowels to shift in the general direction of [u].)

In addition to the evidence in 3, above, there is that from Tigre where, due to assimilatory action, certain short vowels are more back in the environment of labials, especially /w/ (Palmer 1962).

The phonetic basis of this pattern is the fact that labial velars achieve very low 1st and 2nd formant frequencies -- even lower than those of plain labials in most cases (Ladefoged 1964, Lehiste 1964) -- and thus are acoustically unlike sounds at any other than the labial place of articulation. This fact is itself capable of being explained by reference to acoustic phonetic theory (see Ohala and Lorentz).

B. When assimilating to adjacent vowels, it is the labial velar's labial place of articulation that remains unchanged; the place of the lingual constriction may shift or disappear under the influence of the vowel's lingual configuration.

Besides the evidence in 4, above, there is in addition the pattern from Dagbani in which the phonemes /k͡p, g͡b, ŋ͡m/ have the allophones [ȶ͡p, ȡ͡b, n͡m], respectively, before front vowels and the palatal glide /j/ (Wilson and Bendor-Samuel 1969).

There is no mystery about the causes of this tendency. Of the two constrictions of labial velars, only the lingual constriction is free to (partially) assimilate its place of articulation to that of adjacent vowels. The shift of the lingual constriction in such a case is exactly comparable to its shift in other velar consonants, e.g., [k, g, ŋ, x], whose lingual constriction -- as is well known -- is also influenced by neighboring vowels. The labial constriction, for obvious anatomical reasons, is not likely to shift its place of articulation via assimilation to that of the lingual constriction of adjacent segments.

C. When becoming a fricative or determining the place of articulation of adjacent fricatives by assimilation, [w] shows itself primarily as a <u>labial</u>.

In addition to the evidence in 5 (and possibly in 1) above, there are supporting statements such as the following by Heffner (1964: 160):

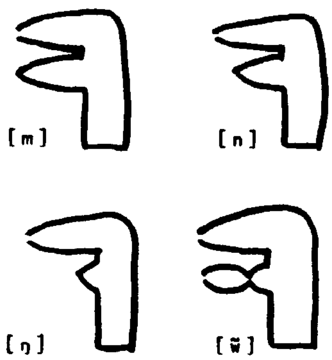
> The fricative noises produced by the articulation of [French] [w] are slight, but such as they are, they come rather from the labial than from the velar constriction.

Assuming that there are both labial and velar sources of fricative noise during these sounds, there are a number of possible phonetic reasons why the labial noise source should predominate. The most important is probably the fact that the configuration of the vocal tract anterior to the velar noise source (the airspace and the small labial constriction) constitute a low-pass filter that effectively attenuates the predominantly high frequency noise produced at the back constriction. The noise source at the labial constriction, of course, suffers no high frequency attenuation.

D. When becoming a nasal or determining the place of articulation of adjacent nasals by assimilation, labial velars behave primarily like <u>velars</u>.

Alongside the evidence in 1 through 5, above, there are many cases such as the dialectal variants for the word for "child" in two Melanesian languages: in Sa'a it is /mwela/ (which is more representative of the original form) but in Kwara 'Ae it is /ŋela/ (Ivens 1931).

The explanation for this pattern requires reference to the vocal tract configurations for the nasal consonants [m, n, ŋ] and [w̃] (to pick a common labial velar), which are represented schematically in Figure 1. Essential to the acoustic characteristics of nasals are the pharyngeal-nasal airway and the oral cavity branching off from it. 'Oral cavity' here refers to that air space extending from the pharynx to the point of constriction. The oral configuration



<u>Figure 1.</u>

anterior to the point of the rearmost constriction has no effect. It can be seen, therefore, that the acoustically relevant configuration of [w̃] is essentially similar to that of [ŋ].

It would seem from these data that the behavior of speech sounds is better understood by reference to system-external factors than system-internal factors. These are not isolated examples. A more appropriate analogy to offer as an image of language would be the game of football (American-style football). At any given time during a football game when the ball is in play, it is still the case, as in chess, that there is "significance" to the game in the special arrangement of the players, e.g. it is advantageous to the side possessing the ball to have an eligible receiver downfield. However, of more importance to the outcome of the game is the inherent ability of the individual players. It may not matter in chess whether one substitutes an ivory chess piece for a wooden one, but does matter in football if one substitutes a 50 kg tackle for one weighing 100 kg.

Conclusion

Observations of universal phonological tendencies -- for example, those found for labial velars, as in the present paper -- force us to the conclusion that the inherent physical constitution of speech sounds, i.e., how they are made and how they sound, have as much or more importance than system-internal relations, in determining the behavior of speech sounds. The emphasis most schools of phonology put on the study of system-internal factors is therefore a mistake.

Acknowledgment

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SYMPOSIUM NO. 1: PHONETIC UNIVERSALS IN PHONOLOGICAL SYSTEMS AND THEIR EXPLANATION

(see vol. II, p. 5-59)

Moderator: John J. Ohala

Panelists: Thomas V. Gamkrelidze, André-Georges Haudricourt, Robert K. Herbert, Jean-Marie Hombert, Björn Lindblom, Kenneth N. Stevens, and Kenneth L. Pike

Chairperson: Bertil Malmberg

JOHN J. OHALA's INTRODUCTION

Phonetic universals is such a large subject that the members of this symposium despaired of being able, in the short time allotted, to give adequate consideration to any of the general aspects of the theory or practice of the field or to solve any of its "great problems". It was decided, therefore, that the moderator would make a few brief general comments about some of these larger issues, more or less "for the record", but that most of the time of the symposium be devoted to the discussion of one very specific problem in the area of phonetic universals.

General Problems and Issues in Phonetic and Phonological Universals

(In this report I will use the shorter phrase 'phonological universals' for the longer, somewhat unwieldy expression 'phonetic universals in phonological systems', the official topic for this symposium.)

1. Before beginning this discussion, we should define what we mean by ***phonological universals***. As this term has come to be used, it means ***systematic patternings of speech sounds cross-linguistically***. This definition does not require that the pattern be manifested in every human language, merely that it have sufficient incidence in the languages of the world such that its occurrence could not be attributed to chance. It is assumed, though, that all languages, indeed, all human speakers, are potentially subject to whatever "forces" create these patterns, but an overt manifestation of these forces may or may not occur and if it does occur, may take different forms. For example, to consider a case discussed extensively by Professor Gamkrelidze, it is presumably the same universal factors which are responsible for the asymmetrical gap in the voiced velar stop position (/g/)

in the segment inventories of Dutch, Czech, and Thai, as are responsible for the disproportionately low incidence of /g/ in the lexicon or in running speech of many languages. Likewise, whatever causes the asymmetrical absence of /p/ in Arabic, Nkom, and Chuave, is also responsible for the limited distribution of /p/ in Japanese, i.e., it only appears intervocalically and as a geminate.

2. The concern with phonological universals in our field has both theoretical and practical consequences. Some 100 years ago our intellectual forefathers, Ellis, Sweet, Passy, Lepsius, Jespersen, and others, provided us, in the phonetic alphabet and the descriptive anatomical and physiological terms accompanying it, the equivalent of the Linnean system of classification in biology or Mendeleev's periodic table of the elements in chemistry. Today, I believe it safe to say that we have reached the stage equivalent to that which Bohr's model of the atom represented in physics and chemistry. We have a framework within which to observe, to describe, and to establish natural classes of phonetic and phonological entities and processes in all human languages. We are also able, with obvious limitations, to predict and explain the behavior of speech sounds. Commendably, in many cases, these explanations are based on empirically-supported models of parts of the speech communication process. Although it is obviously the case that as we deepen our understanding of some of the basic physical, physiological, and psychological mechanisms serving speech, we also are better able to explain many phonological universals; it is also true that in many cases ***it is our observation of phonological universals which leads to a greater understanding of speech mechanisms***. The literature in phonological universals is even now causing us to critically re-examine some of the most fundamental concepts in phonetic and phonological theory, for example, the notions of 'segment', of 'distinctiveness', etc., and to explore in considerable detail in the laboratory basic acoustic aerodynamic, and auditory mechanisms in speech.

In the practical realm phonological universals can aid us in the analysis and understanding of the phonologies of individual languages: they tell us what to look for and they help us to choose alternative scenarios for the history of sound changes in the language. I personally believe that phonological universals can also aid us in such cases of *applied phonology* as speech synthesis, automatic speech recognition, speech pathology, speech therapy, and language teaching. It must be said, however, that at present there has been very little penetration of universals in these areas.

3. Phonological universals are found in many different forms, e.g., segment inventories, segmental sequential constraints ("phonotactics"), allophonic variation, sound change, morphophonemic variation, dialect variation, patterns of sound substitution by first and second language learners, frequency of occurrence of sounds in the lexicon and in connected speech, conventional and esthetic use of speech sounds in onomatopoeia, poetry, jokes, singing, etc. Can we bring all of these disparate phenomena under one theoretical umbrella, using one of these as the base or primitive from which the others may be derived, or, possibly, deriving them from some separate principle external to all of them?

4. Another general issue concerns the problem of how to obtain a truly representative sample of sound patterns from a variety of languages such that the sample is not biassed by including too many or too few languages having certain genetic, typological, or geographical linkages. The many pitfalls of attempting a quantification of phonological data from large samples has been discussed previously, including such concerns as how one differentiates a language from a dialect, whether one should look at the behavior of phones or phonemes and if phonemes, whose conception of the phoneme, etc? The fact is, most works on phonological universals ignore this issue and seem to rely on the investigator's intuitive "feel" for what constitutes a proper sample. Is there any way to make this process objective? How can we create an unbiassed sample; how large should it be?; what criteria should we apply in admitting a language to the sample? Once we have the supposedly unbiassed sample, what type of statistical analysis should we apply to it in our attempts to prove or disprove universal tendencies?

My own solution to this problem, a solution which has parallels in other scientific disciplines, is to make sure that any posited universal is supported both *inductively* -- that is with lots of examples (and few counterexamples) - and *deductively* --

in the segment inventories of Dutch, Czech, and Thai, as are responsible for the disproportionately low incidence of /g/ in the lexicon or in running speech of many languages. Likewise, whatever causes the asymmetrical absence of /p/ in Arabic, Nkom, and Chuave, is also responsible for the limited distribution of /p/ in Japanese, i.e., it only appears intervocalically and as a geminate.

2. The concern with phonological universals in our field has both theoretical and practical consequences. Some 100 years ago our intellectual forefathers, Ellis, Sweet, Passy, Lepsius, Jespersen, and others, provided us, in the phonetic alphabet and the descriptive anatomical and physiological terms accompanying it, the equivalent of the Linnean system of classification in biology or Mendeleev's periodic table of the elements in chemistry. Today, I believe it safe to say that we have reached the stage equivalent to that which Bohr's model of the atom represented in physics and chemistry. We have a framework within which to observe, to describe, and to establish natural classes of phonetic and phonological entities and processes in all human languages. We are also able, with obvious limitations, to predict and explain the behavior of speech sounds. Commendably, in many cases, these explanations are based on empirically-supported models of parts of the speech communication process. Although it is obviously the case that as we deepen our understanding of some of the basic physical, physiological, and psychological mechanisms serving speech, we also are better able to explain many phonological universals; it is also true that in many cases ***it is our observation of phonological universals which leads to a greater understanding of speech mechanisms***. The literature in phonological universals is even now causing us to critically re-examine some of the most fundamental concepts in phonetic and phonological theory, for example, the notions of 'segment', of 'distinctiveness', etc., and to explore in considerable detail in the laboratory basic acoustic, aerodynamic, and auditory mechanisms in speech.

In the practical realm phonological universals can aid us in the analysis and understanding of the phonologies of individual languages: they tell us what to look for and they help us to choose alternative scenarios for the history of sound changes in the language. I personally believe that phonological universals can also aid us in such cases of ***applied phonology*** as speech synthesis, automatic speech recognition, speech pathology, speech therapy, and language teaching. It must be said, however, that at present there has been very little penetration of universals in these areas.

3. Phonological universals are found in many different forms, e.g., segment inventories, segmental sequential constraints ("phonotactics"), allophonic variation, sound change, morphophonemic variation, dialect variation, patterns of sound substitution by first and second language learners, frequency of occurrence of sounds in the lexicon and in connected speech, conventional and esthetic use of speech sounds in onomatopoeia, poetry, jokes, singing, etc. Can we bring all of these disparate phenomena under one theoretical umbrella, using one of these as the base or primitive from which the others may be derived, or, possibly, deriving them from some separate principle external to all of them?

4. Another general issue concerns the problem of how to obtain a truly representative sample of sound patterns from a variety of languages such that the sample is not biassed by including too many or too few languages having certain genetic, typological, or geographical linkages. The many pitfalls of attempting a quantification of phonological data from large samples has been discussed previously, including such concerns as how one differentiates a language from a dialect, whether one should look at the behavior of phones or phonemes and if phonemes, whose conception of the phoneme, etc? The fact is, most works on phonological universals ignore this issue and seem to rely on the investigator's intuitive "feel" for what constitutes a proper sample. Is there any way to make this process objective? How can we create an unbiassed sample; how large should it be?; what criteria should we apply in admitting a language to the sample? Once we have the supposedly unbiassed sample, what type of statistical analysis should we apply to it in our attempts to prove or disprove universal tendencies?

My own solution to this problem, a solution which has parallels in other scientific disciplines, is to make sure that any posited universal is supported both ***inductively*** -- that is with lots of examples (and few counterexamples) - and ***deductively*** --

that is, by what we know to be the underlying operating principl of speech production and perception.

5. A related issue is whether or not some of the claims made about phonological universals may be distorted by observer bias, i.e., be self-fulfilling prophecies. It has been claimed, for example, that all languages code speech in terms of phonemes. But I know of no universally-accepted algorithm which discovers phonemes. And if there were, do we now have any evidence that phonemes and all the properties attributed to them, have psychological and/or physical reality?

A very clear example of the perils of observer bias surrounc claims about universals of syllable structures. It has been claimed that within a syllable, one should not find a transition from voiced to voiceless to voiced. Upon being presented with ar apparent counterexample such as [itv], the claimant would protest that there is a syllable boundary between the [t] and [v]! The potential for similar circularity enters into any claim which contains terms that cannot be objectively defined. And this, unfortunately, is true of a very large number of terms used in phonetics and phonology, including terms such as consonant, vowel, segment, syllable, sonority, strength, lenition, etc.

Would we find a different set of universals if we adopted the parallel, hierarchic system such as Professor Pike advocates? Would we have a different, more interesting set of universals if we included in the description of sounds, as Professor Stevens proposes, the sensory information each sound gives rise to?

A Specific Problem in Phonological Universals

The problem selected for special attention during this symposium is by no means a small one and it is doubtful that it will be solved very quickly, certainly not in the short time allotted us. Nevertheless, it is a problem that intersects with the particular interests of most members of the symposium and is a matter to which many members of the audience can contribute. The problem is stated in a deliberately provocative way in order to stimulate discussion.

The notion of a vowel "space" has been used in phonetics for about 2 centuries but it is only recent evidence which points to this space having acoustic-auditory correlates. The research of Lindblom and his colleagues suggests that the placement of vowels in this space in various languages is dictated by the principle of maximal perceptual difference, i.e., that however many vowels there are in the system, they tend to arrange themselves in the available space in such a way as to maximize their distance from each other. This principle seems to adequately predict the arrangement of systems with approximately 7 or 8 vowels. It would be most satisfying if we could apply the same principles to predict the arrangement of consonants, i.e., posit an acoustic-auditory space and show how the consonants position themselves so as to maximize the inter-consonantal distance. Were we to attempt this, we should undoubtedly reach the patently false prediction that a 7 consonant system should include something like the following set:

ɗ, k', ts, ɬ, m, r, ʔ,

Languages which do have few consonants, such as the Polynesian languages, do not have such an exotic consonant inventory. In fact, the languages which do possess the above set (or close to it), such as Zulu, also have a great many other consonants of each type, i.e., ejectives, clicks, affricates, etc. Rather than maximum differentiation of the entities in the consonant space, we seem to find something approximating the principle which would be characterized as "maximum utilization of the available distinctive features". This has the result that many of the consonants are, in fact, perceptually quite close -- differing by a minimum, not a maximum number of distinctive features.

Does this mean that consonant inventories are structured according to different principles from those which apply to vowel inventories? Could it mean that the "spaces" both consonants and vowels range in, are limited by the auditory features (= parameters) recognized by the particular language? Or does it mean that we are asking our questions about segment inventories in the wrong way?

COMMENTS FROM THE PANELISTS

K.N. Stevens: In an acoustic representation of connected speech we find certain regions where there are rapid (10-30 msec) changes in a number of acoustic parameters, e.g., amplitude, periodicity, and spectrum. A hypothesis that has emerged from our and Chistovich's research, is that the attention of the listener is drawn to these regions, more so than to other regions where changes are less rapid. These regions are, first of all, markers of consonants, but additional information can also be packaged in them along several orthogonal dimensions. We believe languages therefore tend to "select" a consonant inventory that uses up most of these dimensions. These primary dimensions are: [± voice] (presence/absence of periodicity), [± nasal] (presence/absence of low-frequency murmur), [± continuant] (unbroken/interrupted sound), [± grave] (low-/high-frequency tilt to the spectrum), [± compact] (energy spread out/concentrated). After processing the information in these regions of rapid change (= high rate of information transfer), the listener's attention may focus on the remaining regions and here lie the cues for such dimensions as palatalization, pharyngealization, clicks, etc. It logically follows that the learning of (or introduction of) such distinctions will *follow* the learning of distinctions coded in the regions to which primary attention is directed.

B. Lindblom: We have recently followed up and improved on our early work on predicting vowel inventories and I think the research strategy we have used could be applied to consonant inventories, too. Briefly, our procedure is to 1) specify a physiological model of the vocal tract and use it to define 2) the rang of humanly possible vowels and from this derive 3) the (universal human acoustic vowel space, a continuum, and, finally, 4) to employ an auditory model to define a perceptual space to accommodate a specified number of vowels. The last step consists of convolvi an input power spectrum (of a given vowel) with an auditory filte derived from masking data, thus yielding a hypothetical auditory excitation pattern. We assume that, other things being equal, th probability of any two vowels being confused, that is, their perceptual closeness, will be related to the overlap area enclosed b their excitation patterns. We believe vowel systems evolve so as to make vowel identification efficient and this is done by making perceptual differences between vowels (quantified as mentioned above) maximally or, perhaps, sufficiently large. This new measu of perceptual distance yields much more reasonable predictions about vowel placement; in particular, it eliminates the excessive number of high central vowels that plagued previous models.

A preliminary typological study of diphthongs shows that [a^{i}

and [a^u] are the most favored. This result is compatible with the new properties of our model's perceptual space and provides evidence for a principle of perceptual differentiation applying not only paradigmatically, but also sequentially. Consonant inventories can be studied within a paradigm such as this.

K. Pike: My own approach to phonetic analysis is a bit different from that of most of my fellow panelists. Although I have often been helped by acousticians when I have brought my phonetic problems to them, I would rather argue that the reductionism, so necessary in the laboratory, is detrimental to linguistic analysis in the field. I can illustrate this with an examination of a short poem by E.E. Cummings. [Text and detailed commentary omitted.] Although one can point out puns, details of orthography, prosody, and even cultural allusions which contribute to the overall effect, the poem, like language, functions as a whole. I am encouraged by the enlarged scope of phonological inquiry demonstrated at this congress, e.g., the work on syllables. The study of vowel spaces should also be enlarged to include what I call 'pharynx space' (changes in vowel quality by modifications of pharyngeal width and larynx height) and by taking into consideration the psychological reality of vowel structure.

J.-M. Hombert: A surprising number of people I have met at this congress are quite skeptical about the existence of phonological universals. Although one can cite countless examples of cross-language similarities in sound inventories, sound changes, and phonological processes, there are, of course, always counterexamples to almost any generalization one might make. Perhaps the answer to this is to pay more attention to the diachronic aspect of universals: the counterexamples may just be unstable transitional states between more natural states. Moreover, it is often possible to find that certain cited counterexamples cease to be so if one looks into the details more closely, e.g., in cases of tonal development from obstruents, a voiced stop giving rise to a high tone runs counter to the usual patterns, but if it was found that the voiced stop had first become an implosive, an expected development, then the case is no longer a counterexample.

Concerning the sampling problem, mentioned by the moderator, it is particularly acute in the case of perceptual data. This can be solved if we start discovering ways to take our laboratories into the field and thereby gather perceptual data from a wide variety of languages.

R. Herbert: A consideration of the factors constraining the introduction into a consonant inventory of complex sound types, e.g affricates, pre- and post-aspirated consonants, and especially pr nasalized consonants, may provide insight into the constraints on consonant inventories as a whole. Obviously, the parts of such complex segments must be sufficiently different from each other s that they may both be perceptually salient within the time span o a single segment, e.g., the nasal/oral distinction used in prenasalized stops. It must also be possible to articulate the part within this same time span. Thus there are limits on the number of components in single segments: usually 2, but 3 in the case o pre-nasalized affricates, and rarely more. Most such complex sou involve at least quasi-homorganic components, and thus nasal and stop combinations are frequently encountered but lateral and stop combinations less so since laterals, unlike nasals, have limited capacity for homorganicity. We might also speculate that the relative ordering of the components in complex segments is governed by the same factors that determine optimal syllable codas: the first element is generally the more common syllable coda, it bein understood that optimal syllable codas are drawn first from the opposite ends of the sonority hierarchy, e.g., glides, nasals, [ʔ and voiceless stops, before involving segment types from the middle, e.g., laterals, voiced stops, fricatives.

A.-G. Haudricourt: The search for phonological universals seems t me to be like the quest for the philosopher's stone. As for phonetic changes, it is more profitable to look at the conditions fo the appearance of the phenomena rather than for their existence. Language is a social phenomenon and one of its main functions, com munication, causes the development of new phonemes. Sindhi provid an example: its whole series of voiced stops, when long, has become preglottalized in order to remain distinctive. Language also has a socio-ethnic function and so preglottalization may appear without any phonological conditioning, as happens in Vietnamese ar the Henan dialect of Chinese. In these cases, one or two preglottalized consonants are sufficient for the social function and it i normal that they should be the easiest to articulate (ɓ, ɗ). Likewise, preglottalized consonants can disappear for a variety of rea sons. The loss of these sounds in Vietnamese was in part due to the presence of tones (which made the voicing superfluous) but has also been aided by the sociolinguistic environment in, e.g., Saigon. These facts are outside the domain of instrumental phonetics.

T.V. Gamkrelidze: I believe an understanding of the principles governing the structure of consonant and vowel inventories will come from typological phonology and experimental phonetics. An important task for typological phonology today is the establishment of constraints or relations of markedness or dominance between certain bundles of co-occurring features. For example, as detailed in the printed version of my paper, in the subsystem of stops and fricatives, $\begin{bmatrix}+\text{voice}\\+\text{labial}\end{bmatrix}$ is dominant (unmarked) with respect to the co-occurring features $\begin{bmatrix}+\text{voice}\\+\text{velar}\end{bmatrix}$. Thus, among voiced stops, /b/ is dominant, /g/ is recessive. Also, among voiceless stops, /k/ is dominant, /p/ is recessive. These relations stem from the specific acoustic and articulatory properties of the features involved. In the examples mentioned, the volume of the air chambers plays a part. Gaps in the paradigmatic system of obstruents will generally reflect these dominance/recessiveness relations. These relations can therefore help us to better understand sound change and to do language reconstruction more realistically. In light of this, the classical reconstruction of the Indo-European occlusive phonemes appears to be linguistically improbable in that (among other things) it assumes the series with the missing labial were voiced stops. Reinterpreting this series as ejectives brings the IE obstruent system into full conformity with typological studies.

J.J. Ohala: I would speculate that a universal vowel and consonant space does not exist. Each language "chooses" some restricted set of features or dimensions for these spaces. It is common knowledge, for example, that a native speaker of one language is 'deaf' to certain features used in other languages. It is true that the Lindblom model does have a remarkable degree of success in predicting the structure of systems with a small number of vowels. But it is significant that it breaks down when a large number of vowels are involved, very likely because one or two dimensions other than those used in the model are also involved, e.g., vowel duration, diphthongization, voice quality. It could be that vowel spaces, unlike consonant spaces, have rather few possible dimensions and that most languages make some use of the most salient dimensions (those based on spectral shape). In consonant systems, it is well known thε there are more possible dimensions to choose from and so the di crepancy between reality and the predictions of a maximum-percε tual-distance model are more evident. Thus, the differences bε tween vowel and consonant systems in this respect are only appa What is more remarkable --to me, at least -- is the highly symm nature of consonant proliferation. The mechanism of proliferat is reasonably clear, e.g., stop plus [ʔ] yields a glottalized s of stops or ejectives, but why should proliferation almost alwa yield a whole new row or column of such consonants?

DISCUSSION

K.N. Stevens: It is true, as Professor Gamkrelidze notes, that aerodynamic factors contribute to the asymmetries in obstruent systems, but auditory factors are important, too. The noise or burst of a voiceless velar will give a very clear indication of compactness -- more so than a voiced velar, whereas a voiced la will reveal the feature [+grave] better than a voiceless labial

J. Ohala and K. Stevens discussed the need, in the search for t most salient auditory dimensions, of finding the perceptual cue for such striking sounds as ejectives.

K. Pike and J. Ohala mentioned specific instances of vowel and (sonant systems utilizing voice quality as a distinctive dimensi(e.g., certain languages of Nepal, various Nilotic languages, Kor Javanese, Cambodian, Gujarati.

B. Lindblom: It is possible, in principle, to include other dim sions in the vowel space, but it is better at this stage of rese to make our models precise and quantitative. At present then, i is better to restrict the investigation to spectrally-based dime sions. I agree with Ohala that listeners react to vowel stimuli in language-specific ways. In fact, some of our own research sh that Swedish listeners put more subjective distance between the vowels in the crowded front region of the Swedish vowel space th would have been predicted by our model's spectrum-based metric. But let us not be too hasty in discarding the notion of a univer vowel space. After all, this may be what the child brings to th language-learning task.

J. Ohala: I concede that I overstated my position. There undou edly is a universal vowel space and each language chooses a subspace within it. No doubt there is some order according to which features are chosen first.

T.V. Gamkrelidze: The greater proliferation of consonants as opposed to vowels is due to the greater number of possible dimensions in consonant systems. In theory, of course, an infinite number of vowels could be produced, but practically the number is small due to auditory and articulatory constraints.

A. Haudricourt: (In response to a question from J.-M. Hombert) The search for phonological invariants and for culture-specific phenomena is not incompatible, but they are two different problems. First we must investigate the *function* of language and only then look at its phonetic realization.

B. Lindblom: Given the well known *discreteness* of language, it might be asked why, in our model, we start with a *continuous* vowel space. The answer is that we do not yet have a theory that predicts that language should have discrete units such as distinctive features. The theory of distinctive features we do have is based on induction. I think the discreteness has to be deduced or derived as a consequence of more fundamental principles. Even so, a totally discrete model will still not explain why, in languages with few vowel contrasts, the extreme corner vowels tend to be phonetically less extreme (as noted by Crothers).

(To Prof. Stevens:) The quantal phenomena you find in the articulatory-to-acoustic transformation cannot be the only source of phonological discreteness. Surely, memory mechanisms must be involved as well (cf. the work of G. Miller and I. Pollack on elementary auditory displays).

K. N. Stevens: I agree with all of your points. I would just say that in the vowel space there are some regions which are more stable (or discrete) than others in that a wide range of articulations would give rise to the same acoustic signal. So the vowels will be within these regions, the exact location determined by factors such as your model incorporates. It is possible, too, that the whole space may shift in one direction or another due to different so-called 'basis of articulation' of various languages.

B. Lindblom: Isn't this a denial of the possibility for a universal framework?

K.N. Stevens: I don't think so. I view these shifts as being fairly small. The high front vowels in various languages may not be phonetically identical, but they are still high front vowels.

K. Pike: It won't work to say it is either 'discrete' or 'conti uous'. We need 'particle' or 'wave' descriptions, both of which observer-related, *and* a 'field' view which describes it in terms of an overall system.

C.J. Bailey and T.V. Gamkrelidze expressed differing views on ho much weight to give to typological evidence as opposed to compar ative (within-family) evidence when doing reconstructions.

C. Scully: A propos of pre-nasalized stops, I have found in air flow traces that the velum closes very late during the closure p tion of post-pausal voiced stops, almost as if some aspects of speech are begun while certain acts of respiration (open velum) still in play. This may be a good example of a mechanically det mined feature of pronunciation that might become generalized and taken up as a linguistic feature.

S. Anderson: I wish to take issue with the assumptions (or by Ohala, an explicit proposal) that claims about phonological stru tures must be verifiable in terms of substance in some other do- main, typically phonetic. At the Phonology session of this congr I sketched a rather different approach to phonology which assume that there is a systematic domain which is relevant to the nature language but which isn't directly reducible to other domains. Ac cording to this view, the facts that are directly susceptible of phonetic explanations are, in a sense, exactly what is irrelevant to phonology.

F. Longchamp: (To Hombert) You haven't made a clear case for th decreased saliency of the centralized vowels. The vowels that be haved oddly in your study seem to be the one-formant vowels. Of course, subjects can give labels to these vowels but this may hav no relevance to natural speech.

H.-H. Jeng: I think child language studies can provide evidence relevant to the questions on the elaboration of segment inventori In the early speech of my son the consonant system used only the features for ± stop and those for different places of articula- tion. Later on, features were added to differentiate nasality, aspiration, frication, etc. In the case of vowels, only height features were used at first. Later, front-back and rounding were differentiated. I think these early segment systems represent th universal core upon which further elaborations of the system can be built.

N. Waterson: I question the phonemic basis used in work on universals. There is much evidence that the proper domain of many phonological processes is something more like the word. In sound change the position of the sound in the word and its phonetic context is very important. Children will often produce the correct degree of vowel openness in vowels in a 2-syllable word but not the correct frontness or rounding feature. Thus, when looking for universals we should look for patterns in the domain of the whole syllable or word.

H. Andersen: I don't see how Lindblom's model will accommodate vowel mergers which are very common diachronically. Nor can this problem be solved as recommended by Hombert by assigning the merged vowels to an unnatural transitional state which will eventually revert to a stable natural state. How is one to identify transition as opposed to stable state? The solution, I think, is to recognize that the vowel (as well as the consonant) space is used for more than just diacritic purposes: they also carry information about their consonant environment, about the style of speech used by the speaker as well as his age and social class membership. Thus when the vowels slide around it must be because these subsidiary functions lose their value and are re-interpreted as basic values of the vowel phonemes themselves. This notion is fully in accord with the views expressed here by Profs. Pike and Haudricourt.

L. Jacobson: I can provide some more details on the vowel systems of certain Nilotic languages (alluded to by Ohala) and and at the same time show that they are compatible with Lindblom's model. My own acoustic analysis of the 9 vowel system of Luo shows that many of the non-low vowels show great overlap in an F1 x F2 x F3 space.. They can be separated, however, by adding a dimension of voice quality (or pharynx size): breathy voice vs. normal or creaky voice. When this is done, all the vowels are still maximally distant from the other vowels *on the same plane*.

I. Maddieson: It was mentioned (by Lindblom) that high vowels in systems with few vowels tend to be less peripheral. This is a crucial fact and suggests that *maximal* dispersion of entities in an auditory space isn't required. I fihd supporting evidence for this view in the structure of tonal spaces: words borrowed from a 2 level-tone language into a 3 level-tone language reveal that the high tone of the 2-tone language is equal to the mid-tone of the 3-tone language, the implication being that systems with 3 tones use of the available tone space than do those with 2 tones. We co explain all this as well as the pattern of elaboration of cons systems by the generalization: additions to these spaces firs volve pushing the boundaries of the existing dimensions and th recruiting additional dimensions for additional contrasts.

L. Lisker: Is the search for universals a viable enterprise i can't be sure that we are aware of all the features that human guages make use of? New ones are discovered all the time. Al when making generalizations about segment inventories, we shou be clear what we're talking about: the /g/ in English is not same 'beast' as the /g/'s in Spanish or French, for example. problem is that the C's and V's we count are invariably the pr of the phonologist who uses other than purely phonetic criteri deciding how to classify sounds.

H. Galton: Considering cases like Ubykh,a Caucasian language 80 consonants and no more than 2 vowels, and English with about 1/3 as many consonants and many more vowels, I wonder if Prof. Gamkrelidze would accept the tentative universal that is there a kind of balance between a language's consonant and vowel inve tories, i.e., that one develops at the expense of the other?

T.V. Gamkrelidze: The number of consonants always exceeds that vowels since the possibilities for auditory and articulatory co trasts is greater for consonants.

J. Ohala: Regarding the relative merits of a formalist vs. a p icalist research strategy in phonology, the issue raised by Pro Anderson, I suggest this be decided by examining the 'track rec of the two approaches in providing explanations in phonology.

Reflecting on several of the comments made here, I would s gest we consider the possibility that the single multi-dimensio perceptual space that *both* consonants and vowels range in is no simply defined by the various spectral features (F1, F2, F3), a plitude, periodicity, etc., but rather the first derivative --t rate of change-- of those features. R. Port at Indiana as well Lindblom have explored this possibility. In this case, the uni would no longer be phonemes as such, but rather the transitions between them. These units (more numerous than phonemes) tend t more invariant, too.