From UPSID to PRUPSID
A Phonetic Reanalysis of the UCLA Phonological Segment Inventory Database[1]

Tom Van Hout
Department of Germanic Languages • Universiteitsplein 1 • B-2610 Wilrijk
tom.vanhout@ua.ac.be

0. Introduction

Human language only uses a subset of sounds that are physiologically possible. Within this subset there is a core of widely recurring sounds. The structure and frequency of these speech sounds is extensively described in UPSID – the UCLA Phonological Segment Inventory Database (Maddieson 1984), a landmark publication in comparative phonology and point of departure for PRUPSID , a Phonetic Reanalysis of UPSID data. The reanalysis presented here is suggestive rather than exhaustive. It aims to illustrate the enormous research potential of the UPSID database by reanalyzing a specific section of this relatively untapped source of phonological information. The main focus is on phonetic universals[2] in phonological systems; a position that bears directly on the relationship between phonetics and phonology.

Phonetics can be roughly defined as 'the scientific study of speech'. The equivalent definition for linguistics would be then 'the scientific study of language'. Phonetics is concerned with articulatory, acoustic and perceptual properties of speech sounds; linguistics concentrates on form, meaning and function of language, whether spoken or written. This division between speech and language is a central one and is courtesy of Abercrombie (1972: 1-3). He distinguishes between "language" on the one hand and the "medium"[3] expressing language on the other. The medium carries information in languages and can be visual (in writing), aural (in speech) and tactile (in Braille), among

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[2] The concept of a (phonetic) universal is a cover term denoting essential language properties – those that hold true of all languages – and typical language properties – those that represent the norm (Whaley 1997: 51).

[3] Abercrombie points out that the medium is a human artifact. Besides conveying linguistic information, the medium also informs about our mood, social and regional affiliation and overall identity. The various dimensions of the medium are extensively described in Verhoeven (forthcoming).

others. Moreover, Abercrombie states that language exists in *patterns* formed by the medium in question. He concludes that language is *form* and medium is *substance*.

This distinction separates phonetics and linguistics, and more specifically, phonetics and phonology[4]. Form pertains to pattern identity in relation to linguistic units, while substance appeals to the medium embodying linguistic patterns. In this connection, phonology can be seen as the study of the form of spoken language, and phonetics as the study of the substance of spoken language (Laver 1994: 20). In its essence, however, phonetics does not take the meaning or function of speech sounds within a language system into account, phonology does just that. Indeed, "phonetics differs from phonology […] in that it considers speech sounds independently of their paradigmatic and syntagmatic combinations in particular languages." (Lyons 1987: 24). As such, phonetics is usually placed outside the realm of linguistics.

This narrow perspective is not always warranted. Arguably, linguistics and phonetics share a common domain in phonology – the study of spoken language. Linguistics sheds light on the communicative nature of spoken language, while phonetics examines speech production and perception in function of phonological patterns. This broader view on phonetics, which is adopted throughout this paper, is characteristic of *linguistic phonetics* – the study of spoken language from a phonetic perspective (Ladefoged 1971, 1997). Ultimately, "its objective is to describe the phonetic correlates of phonological units of spoken language and their interactions" (Laver 2001: 150-1), thereby validating phonetic explanation in phonology – a subject broached by Diehl (1991), among others. Within this perspective of linguistic phonetics, the focus is on phonetic factors underlying the size and structure of phonological inventories[5] in the world's languages.

Linguistic typology naturally calls for data from a wide range of languages. With reference to the viability of phonetic analyses of phonemic inventories – PRUPSID's focal point – two theoretical assumptions must be made: *cross-linguistic comparability* and *uniformitarianism* (Song 2001: 9-16). The former assumes that the subject of comparison is the same across languages. Apparently self-evident, the issue is not straightforward. For example, English and Hindi make contrastive use of an unaspirated stop /p/. Hindi also has an aspirated /p^h/. Phonologically the problem is, how can one identify English /p/ with Hindi /p/ if the phonemic system is different? Phonetically, it is difficult to see which Hindi phoneme should be identified with English /p/. Nevertheless, the validity of comparative phonological typology depends on the degree

[4] Ohala (1997) documents the division between phonetics and phonology from a historical point of view.

[5] For a plausible phonological account of inventory size and structure, the reader is referred to Lindblom, MacNeilage & Studdert-Kennedy (1984).

of comparison between the linguistic system on the one hand and its phonetic manifestation[6] on the other (Croft 1990: 18). The assumption of cross-linguistic uniformitarianism provides a frame of reference for typology: assuming qualitative similarity between extinct and extant language systems, it justifies the inclusion of extinct languages in typological studies. There is no reason to believe that extinct languages are in any way less representative of human language than extant languages are. Thus, for phonological typology to be a viable research area, it has to be assumed that phonemes are comparable and uniform across languages, whether extinct or extant. But do these assumptions validate phonetic explanation in linguistic typology? Probably not. Samples are based on grammatical categories, e.g. SVO versus SOV languages, and not on phonetic distinctions. For example, samples made up of click versus non-click languages do not exist to my knowledge. Such phonetic samples may harbor other fundamental insights. For the time being, however, we will have to work with grammatical samples like UPSID and the framework of linguistic phonetics for describing the phonetic dimensions of phonological data.

Like UPSID, PRUPSID aims "to provide uniform data from a properly balanced sample of an adequate number of languages for statistically reliable conclusions to be reached" (Maddieson 1984: 156) about the size and structure of stop inventories. Section 1 explores the scope and aims of the theoretical perspective of linguistic phonetics, with specific reference to Laverian phonetic theory. The theoretical construct of aspects of articulation allows for the extension of the traditional category of stops. A phonemic analysis of stop segments is clearly open to empirical test, provided that an acceptably representative sample of the world's languages is available.

Representative language samples are the bread and butter of linguistic typology. The Diversity Value Method of Section 2 meets Goyvaerts' (1975: 15) criteria of representativeness: it is non-arbitrary (it is applicable to any given sample size and genetic classification); exhaustive (the method applies to all natural extant and extinct languages); and unique (no language falls into more than one classification). Consequently, it is assumed that PRUPSID deals with observations about a genetically, typologically and areally stratified sample of languages, considered to be representative of the whole universe of human language, while keeping in mind that it remains unclear what kind of sample, if any, actually has "an adequate number of languages".

[6] As a metric for comparing the phonetic properties of any two sounds, Laver (2001: 155-6) uses a concept of phonetic similarity. This concept allows for the grouping of (phonetically similar) allophones into a single phoneme and it sheds light on the orthographic representation of phonetic segments.

Section 3 hypothesizes that phonetic factors underlie the size and structure of stop inventories by addressing two fundamental questions. Firstly, how do the proportions of stop articulations vary in relation to inventory size: how many phonologically contrastive stop segments may a language have? And secondly, how do languages select stops in relation to inventory structure – as gauged by a hypothetical stop inventory?

1. Theoretical framework

The nature of this paper – reanalyzing a phonological database in light of phonetic universals – calls for an increased scope of traditional phonetic theory as promoted by the International Phonetic Association (IPA). The theoretical perspective of linguistic phonetics answers this call.

The perspective of linguistic phonetics (Ladefoged 1971, 1997) can be defined as the study of spoken language from a phonetic viewpoint. As such, only phonologically contrastive speech sounds are considered. More precisely, the scope of linguistic phonetics entails form: "all the encoded aspects of speech except those [of the medium] that convey linguistic information about the speaker's identity, attitude, emotions or sociolinguistic background, in so far as these are not conveyed by syntactic or lexical devices" (Ladefoged 1997: 590). In other words, linguistic phonetics aims at describing sound patterns. As such, it contributes to phonology the phonetic understanding of performance constraints governing sound patterns across and within languages. At the same time, the framework contributes to phonetics a phonological understanding of the set of possible human sounds that can be used linguistically. The latter especially lies at the heart of PRUPSID.

In light of describing the phonetic correlates of phonological units, linguistic phonetics draws on general phonetic and phonological theory. The shape of a phonological theory is discussed in Ladefoged (1997). Phonetically, PRUPSID adheres to Laver's (1994) *Principles of phonetics*, which "undertakes to refine categories in an effort to be both comprehensive and consistent" (Ingemann 1997: 172). The following section briefly summarizes the basic notions and principles of Laver's refinements.

Essentially, Laverian theory claims that its "posited features and organizational units cover the maximum range of data with the simplest descriptive constructs" (Laver 2001: 154). Laver segments speech into linear units and classifies them in a predominantly articulatory[7] perspective in terms of the maximum degree of vocal tract constriction reached during the medial phase of segmental production.

In his componential approach to segmental classification, Laver (2001: 160) distinguishes five subprocesses in the production of speech: initiation and direction of airflow; phonation type; articulation; intersegmental co-ordination; and temporal organisation (duration). Laver (1994, 2001) discusses all five components in detail. This paper only focuses on segment articulation.

The component of articulation specifies the relationship between phonetic segments and features in terms of the classificatory principles of place of articulation, degree of stricture, multiple degrees of stricture and aspect of articulation. A convenient fiction in this classification is that of segmental phasing in onset, medial and offset phases.

In terms of place of articulation, Laverian theory distinguishes between place-neutral segments "made by an active articulator interacting with its anatomically neutral passive articulator" (Laver 1994: 137) and displaced articulations – "where the active articulator is displaced from its anatomically neutral position" (Laver 1994: 137). The former comprises labial, dental, alveolar, palatal, velar, uvular, pharyngeal, epiglottal, glottal articulations; the latter captures linguolabial, labiodental, interdental, laminodental and apicoalveolar stricture locations. Laver (2001: 167) observes that the "distinction between neutral and displaced articulations amounts to a claim about the relative frequency of incidence of different sounds in the languages of the world. The simpler, less elaborate concept of neutral articulations underpins a broadly sustainable assumption that neutral labial, dental, alveolar, palatal, velar, and glottal sounds are more frequently encountered, for instance, than the displaced linguolabial, labiodental, and apico-alveolar sounds." Such a claim is clearly open to empirical testing, provided that a representative language sample is available. For the record, PRUPSID has not verified this claim explicitly, but my overall impression firmly supports Laver's claim.

As far as the degree of articulatory constricution is concerned, Laver divides speech sounds into three classes. *Stops* are characterized by complete articulatory closure; *fricatives* have a close approximation; *resonants*, both vocoid and non-vocoid, can be recognized by their stricture of open approximation. But as was noted before, Laver's theory (1994: 134-5, 244, 269) also employs a perceptual criterion – the presence or absence of *audible friction* during articulation – in the classification of speech segments. This perceptual criterion need not concern us here, since PRUPSID

[7] Jo Verhoeven has indicated to me that Laver's theory uses perceptual concepts in the classification of speech segments as well. For example, fricatives are defined by their degree of "audible friction" (Laver 1994: 244) during close approximation of the articulators.

concentrates on stop segments, which can be articulatorily defined by a stricture of complete closure in the oral cavity.

The final classificatory principle has to do with aspect of articulation. If the primary goal of phonetics is the description and classification of speech sounds, it is in the best interest of the science to constantly scrutinize its existing frameworks and theoretical assumptions. The work of 20th century European phoneticians such as Daniel Jones (1967), David Abercrombie (1972), Peter Ladefoged (1975), and Ian Catford (1977) has laid down the descriptive foundations for what has become mainstream phonetic theory. Credit is due to the IPA for safeguarding this heritage of phonetic terms and symbols. Unfortunately, this association is reluctant to change; in its hundred years' existence, the descriptive framework maintained by the IPA has not known major changes. The architecture of the IPA framework can be read off directly from its phonetic alphabet charts. For example, these charts reveal a perceptual flavor (e.g. in its terminology: 'plosive') and an orientation towards the description of neutral articulations – being stops, fricatives and resonants performed "with the tongue in a regularly curved shape (convex both longitudinally and laterally), with the velum closed, and with a stricture maintained more or less as a steady state throughout the medial phase in a single, neutral place of articulation" (Laver 2001: 169). From a non-neutral – and therefore very innovative – point of view, there are three so-called aspects of articulation that merit description according to Laver (1994). These aspects relate to conformation of the air channel – *conformational aspects* – topography of the active articulator, i.e. the shape and surface of the tongue – *topographical aspects* – and transition of the articulation – *transitional aspects*. The following briefly describes these aspects in comparison with IPA classification.

Conformational aspects describe the route, course and obstruction of the air-channel. In the *oral versus nasal* aspect, the position of the velum is critical. Speech sounds articulated with velic closure are said to be oral. Nasal articulations are by definition produced with a lowered velum so that the airstream can flow freely through the nasal cavity. This defines segments with a nasal aspect of articulation. Note that the IPA does not recognize the oral versus nasal aspect as a modifying feature applicable to stops, fricatives and resonants. Citing Laver (1994: 586) once again, "the disadvantage of the IPA classification of nasal stops as an independent segment-type on par with oral stops is that the commonality of nasality being applicable as a modifying feature to all three basic stricture types (stop, fricative and resonant), with oral versions of these counting as neutral, is then lost".

A second conformational aspect relates to *central versus lateral* steering of the airflow channel. In this case, the main factor is the influence of a constriction in the oral cavity on the routing of the airflow. If the air escapes around an obstacle, the airflow is said to be lateral. In absence of such an obstacle, the airflow is said to be central. As was the case previously, it can be argued that the IPA classification is at a disadvantage in this sense as well – provided that clicks are regarded as stops essentially. By classifying lateral fricatives and lateral approximants on par with central segments, the IPA blurs the commonality of a lateral aspect applicable to stops[8] (e.g. a voiceless alveolar lateral click /k!/), fricatives (e.g. a voiceless alveolar lateral fricative /¬/) and resonants (e.g. a voiced alveolar lateral approximant/contoid[9] /l/).

A third conformational aspect concerns *single versus multiple strictures*. In the default setting, segments are characterized by a single stricture, e.g. oral stops. Double and secondary articulations exemplify segments with multiple strictures. Any IPA consonant chart lists only those segments with single strictures. Multiple stricture segments are miscellaneously listed in categories such as 'other symbols' or 'diacritics'. Transverse topographical aspects cannot be found in any IPA segmental classification. Here too, the applicational commonality of the lateral aspect to all three stricture types is lost in an IPA perspective.

Topographical aspects describe how the convex shape of the tongue surface changes during articulation. On the basis of the tongue's front-to-back and side-to-side movements, Laver (1994: 141) distinguishes two categories. Firstly, *longitudinal* topographical aspects come in four categories: retroflexion; withdrawn tongue tip; extension of the tongue tip and advancement of the tongue root, of which all but the withdrawn tongue tip phenomenon apply to all segment types. The IPA classifies retroflexion as a place of articulation, to be situated in between the alveolar ridge and palate. While retroflex articulations probably can be characterized by a stricture at such a place in the oral cavity, it is important to realize that retroflexion is not a place of articulation *per se*, but rather a modifying feature again applicable to all three stricture types. A right-curling descender (e.g. /Í/) symbolizes both withdrawal of the tongue tip and extension of the tongue tip – two concomitant features of retroflexion.

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8 Note that this position is in sharp contrast with Laver (1994: 211), who writes that stops "are logically excluded from any choice between central versus lateral routing of the oral airflow since complete oral closure during the medial phase is a prerequisite for being classified as a stop segment". But, seeing that (lateral) clicks are essentially combinations of stops, I have to disagree with Laver on this account.

9 The distinction between central and lateral aspects of articulation is instrumental in Laver's (1994: 147-149) division of sounds into contoids and non-contoids, which are further subdivided into approximants when non-syllabic and vocoids when syllabic – thereby replacing the phonological terms vowels and consonants. Although a phonetically motivated distinction, Ingemann (1997: 173-174) calls Laver's "new definitions of old terms […] an unnecessary stumbling block".

Secondly, *transverse* topographical aspects pertain to grooving of the tongue surface and cupping of the tongue surface. These dimensions cannot be expressed adequately in IPA classification since there are no means of symbolizing them.

Transitional aspects concentrate on the movements of the vocal organs "when a steady state is not maintained during the medial phase of segments." (Laver 1994: 142). These phenomena are known as *flapping*, *tapping*, and *trilling*. The IPA analyzes flaps, taps and trills not as modifying features, but rather as independent segment types equal to stops, fricatives and resonants. Laver – and hence PRUPSID – applies flapping to stops and lateral resonants; tapping to stops and fricatives; and trilling also to stops and fricatives.

Transitional aspects of vocoid articulation allow for the analysis of *monophthongs* and *diphthongs*. Laver (1994: 284) defines a monophthong as "a vocoid where the medial phase shows a relatively stable articulatory position of the tongue and the lips." Diphthongs are then defined as segments characterized by an "articulatory trajectory across the vocoid space" (Laver 1994: 284), with the trajectory ranging from relatively simple to complex. Vowel symbols and combinations thereof can represent transitional aspects of vocoid articulations.

In summary, the aspects of articulation systematically capture non-neutral dimensions of the mechanics of speaking. Contrary to the IPA, the aspects modify all three basic stricture types (stop, fricative and resonant) by assigning one or more features to each stricture type. Essentially, "[t]he underlying motivation for setting up the concept of aspects of articulation, apart from making the overall classification of segments more rational, is the fundamental conviction that the concept of degree of stricture is articulatorily, acoustically and auditorily dominant in the way that languages exploit the phonetic possibilities of speech" (Laver 1994: 140).

This – perhaps radical – new perspective reanalyzes IPA classifications, by recognizing only three stricture types, which are then further modified by the aspects of articulation. Figure 1 illustrates the applicability of these three types of aspects of articulation to segment types. A direct result of this reanalysis is that traditional categories can be extended. Case in point is the IPA category of stops. If the oral versus nasal conformational aspect applies to stops, then what the IPA terms nasal segments are actually stops (with a nasal aspect). This position is in sharp contrast with Maddieson (1984: 165), who writes, "nasals are not considered to be stops of any sort". Ejective, implosive, affricated stops and combinations thereof can also be thought of as stops with an oral aspect combined with a non-neutral airstream mechanism and articulatory trajectory respectively.

Figure 1: Applicability of aspects of articulation to segment types.

Aspects of articulation	**Conformational**	• oral versus nasal *(stops, fricatives and resonants)* • central versus lateral *(stops, fricatives and resonants)* • single versus multiple strictures *(stops, fricatives and resonants)*
	Topographical (convex/concave tongue surface)	• grooving *(fricatives)* • retroflex *(stops, fricatives and resonants)* • cupping *(stops, fricatives and resonants)* • tongue tip extension *(stops, fricatives and resonants)* • withdrawn tongue root (resonants) • advanced tongue root *(stops, fricatives and resonants)*
	Transitional (steady/dynamic)	• flapped *(stops and lateral resonants)* • tapped *(stops and fricatives)* • trilled *(stops and fricatives)* • diphthongal *(resonants, e.g.* [aɪ] *in English 'flight')*

The same rationale holds for stop segments with multiple strictures. Double and secondary articulations can therefore be classified as stop segments with a conformational aspect of multiple strictures. On the same grounds, some retroflex segments are stops with a topographical aspect. Again, note that the IPA classifies retroflexion as a place of articulation. With the help of aspects articulation, retroflex /Í, ˜, }/ can be classified as stops, with say a palato-alveolar place of articulation[10]. Observe that the above series included a retroflex tap/flap, which leads us to another set of segments that can be added to the category of stops, namely those stops that are characterized by a transitional aspect: tapped, trilled, flapped stops. So, the applicability of aspects of articulation allows for the extension of the traditional category of stops. In PRUPSID, a stop segment thus becomes a cover term for oral and nasal pulmonic stops, ejective and implosive stops, clicks, double and secondary stop articulations, affricated stops, ejective affricates, affricated clicks, and lastly, tapped, flapped, and trilled stops.

2. Sampling method

2.1 UPSID

UPSID contains the segment inventories of 317 languages "chosen to approximate a properly constructed quota sample on a genetic basis of the world's extant languages" (Maddieson 1984: 5). The quota rule selects "one and only one language from each moderately distant genetic grouping, so that the selected languages represent in proper proportion the internal genetic diversity of various groupings" (Maddieson 1984: 158)[11]. As such, inclusion of the same language in several varieties (i.e. dialects) is eliminated, while at the same time respecting the genetic diversity of language families. However, establishing the concept of a "moderately distant genetic grouping" is not so obvious. Bell (1978) chose a time depth of 3500 years to determine genetic distance, resulting in 16 language families, 478 daughters and 4300 languages. Through a synthesis of several language classifications, and "an intention to include no pair of languages which had not developed within their own independent speech communities for at least some 1000-1500 years, but to include one language from within each group of languages which shared a history closer than that", Maddieson (1984: 158-9) arrived at eleven major families and one miscellaneous group (see table 1). Availability and

[10] Other topographical aspects concerning stops are ignored since these dimensions are not used contrastively.

[11] The term 'grouping' is used synonymously here with '(language) family' or '(linguistic) phylum'. These three terms are used interchangeably throughout this paper.

quality of phonological data decided on inclusion, number of speakers or phonological peculiarity of a language did not[12] (Maddieson 1984: 5).

An example may illustrate this selection procedure. In the Indo-European superfamily, the Germanic language tree branches out into North, West and East Germanic. One language was included from each primary branch; Norwegian (North Germanic) and German (West Germanic). Gothic, an East Germanic language, was not included because the UPSID sample is restricted to extant languages.

Maddieson (1984: 160) admits that his sample does not live up to its design specifications due to a lack of adequate data for some languages: "an educated guess is that overall the present sample contains between 70-80% of the languages that it should include in order to completely fulfill its design specifications". Ultimately, a total of 317 languages constitute the UPSID sample[13]. The language families and number of included languages in the UPSID sample are given in table 1. Note that the Amerindian language family has 88 representatives in the UPSID sample. For a genetic overview of the actual UPSID sample languages, the interested reader is referred to Maddieson (1984: 174-177).

Every UPSID entry is a phonemic representation of its "most characteristic allophone" (Maddieson 1984: 6), analyzed by a set of phonetic attributes. The analysis of phonologically contrastive segments results in a phoneme inventory for each UPSID language. Determining these phoneme inventories boils down to two aspects: how many contrastive units are there in a given language and what phonetic properties do we assign to each one? The first aspect requires a definition of the notion 'contrastive' and a decision on the choice between a unit or a sequence interpretation of complex articulations such as affricates and prenasalized stops. Maddieson (1984: 161) defines contrastive units as "sound differences capable of distinguishing lexemes or morphemes in the language involved". As a rule of thumb, if complex consonantal articulations can be split by a morpheme boundary, or if they are part of non-homorganic clusters (e.g. /sk/), they were analyzed as sequences of simpler segments. On the other hand, if they

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[12] However, phonological peculiarity will more than likely have been a factor in deciding on the inclusion of the Khoisan languages Nama and !Xù in Maddieson's miscellaneous category.

[13] Note that a new and improved version of the UPSID sample exists as MS-DOS software: "This version improves the sample, increasing coverage of previously undersampled language families and correcting a few oversampling errors, and correcting errors in individual language inventories" (Maddieson and Precoda 1989: S19). This updated sample contains data on 451 languages and "provides economical and flexible means of storing and modifying this enhanced database and outputting subsets of the data for further analysis" (Maddieson and Precoda 1989: S19). The software package can be ordered directly from the UCLA Phonetics lab (www.linguistics.ucla.edu/faciliti/sales/software.htm). Similarly, Ron Brasington has made a MacIntosh-compatible interface based on the original 317-language sample. More information: http://www.linguistics.rdg.ac.uk/staff/Ron.Brasington/UPSID.interface/Interface.html.

feature in a non-alternating morpheme or if they do not belong to such a cluster set, the complex articulations were interpreted as unitary segments (Maddieson 1984: 161). The second aspect concerns phonetic specification of a segment; what is the procedure for identifying the most representative allophone? The selection procedure was based on these three questions (Maddieson 1984: 163):

- Which allophone has the widest distribution (i.e. appears in the widest range of and/or most frequently occurring environments)?
- Which allophone most appropriately represents the phonetic range of variation of all allophones?
- Which allophone is the one from which other allophones can be most simply and naturally derived?

In cases of conflicting answers, Maddieson (1984: 163) chose the answer that "did least violence to all three considerations taken together". This consideration reveals that phonemic analyses are no simple matter[14]. In their review of *Patterns of sounds*, Pagliuca & Perkins (1986: 370, emphasis added) raise an even more important point. They argue that "investing a contrast unit (which is NOT a phonetic entity) with phonetic status in order to arrive at universals about the phonetic content of contrast units" is problematic. Although they are treated as such, contrast units or phonemes are not each other's principal allophones; they are – if anything – the set of their various phonetic realizations. For example (after Pagliuca & Perkins 1986: 369), in UPSID, Spanish has a voiceless stop series and a voiced fricative series. Now, what could be analyzed as voiced stop phonemes having fricative allophones is instead represented by [B] [D] [F] namely their "most characteristic allophones". Therefore, the reviewers (Pagliuca & Perkins 1986: 370) conclude, we should "be careful not to read the results […] as if they were informing us about all the phonetic dimensions the UPSID languages make use of, or the number of dimensions a given language or language type exhibits."
Lastly, 192 of the 317 UPSID languages have benefited directly from the readily accessible Stanford Phonology Archive (SPA), a source of standardized phonemic analyses. On some accounts, UPSID differs from SPA in terms of decisions on

[14] For example, deciding on the number of allophones per phoneme is no trivial task in itself. As Laver (1994: 578) correctly observes, the "union of contextual and structural influences […] gives birth to a multitude of [phonetically differentiable] allophonic offspring, which make up the family of sounds representing a given phoneme in any language. Reaching a practical selection of such 'most representative' allophones, if the full power of descriptive phonetic theory were to be applied, would therefore have to appeal to very wide-ranging and often perhaps somewhat intuitive criteria."

phonemic status and phonetic descriptions, prompting reanalyzes of some languages. SPA also has a much broader scope; UPSID does not inform about allophonic variation, syllable structure and phonological rules. Phoneme charts for all 317 languages can be found in *Patterns of sounds* (Maddieson 1984: 263-422).

Table 1: UPSID language families (adapted from Maddieson 1984: 159) [15]

Language family		**Number of included languages**
Indo-European		21
Ural-Altaic		22
Niger-Kordofonian		31
Nilo-Saharan		21
Afro-Asiatic		21
Austro-Asiatic		6
Australian		19
Austro-Tai		25
Sino-Tibetan		18
Indo-Pacific		27 (sic! 26)
Amerindian (North and South)		89 (sic! 88)
Miscellaneous		18 (sic! 19)
(including Eskimo-Aleut, Dravidian, Paleo-Siberian, Caucasian languages, and also Nama, !Xù‡ (Khoisan), Basque, Burushaski and Ainu)	total	317

In UPSID, the phonetic description of segments is uniformly specified in a list of phonetic attributes. Every segment is binarily coded according to these attributes. The description of segments thus equals the list of attributes for which it has the value 1. As far as consonants are concerned, UPSID specifies voicing, place and manner of articulation. Secondary articulations are also included in the attributes. In total, some 45 phonetic parameters are used in the description of consonants, the majority of which

[15] In fact, the total number of languages in table 1 adds up to 318 and *not* 317, the number which is mentioned throughout *Patterns of Sounds* and other publications about UPSID [e.g. Lindblom & Maddieson (1988), Stevens and Keyser (1989)]. Apparently, three typos are the cause. In an appendix, Maddieson (1984: 174-7) genetically outlines the UPSID sample languages. This allows for a quick recount of sampled languages per language family, which in turn reveals that the UPSID sample uses only 26 Indo-Pacific languages (not 27), 88 Amerindian languages (not 89) and 19 miscellaneous languages (not 18).

also apply to stops[16]. In comparison to Laver's descriptive framework, these parameters "are in all cases either directly equivalent to or readily translatable into the phonetic dimensions described in this book [*Principles of phonetics*]" (Laver 1994: 578). The UPSID variables are extensively described in Maddieson (1984: 163-170).

2.2 PRUPSID

The PRUPSID sample was created using the Diversity Value (DV) method as described in Rijkhoff, Bakker, Hengeveld & Kahrel (1993) and in Rijkhoff & Bakker (1998).

As outlined above, the UPSID sample hinges on two genetic criteria: diversity and distance. The former is well-documented and widely used in cross-linguistic research and language classifications, the latter is not. As Pagliuca & Perkins (1986: 372) observe, the "lack of a principled basis for deciding on the appropriate minimum genetic distance separating any two languages in a sample should make us wary of using presumed time-depth as the basis for the size and distribution of a language sample." One alternative has been to sample genetically independent languages (i.e. languages that have only a very distant or no genetic relation at all [cf. Bybee (1985), Perkins (1989)].

The main problem with this sampling technique is the danger of areal bias; it may not be possible to construct a sample of independent languages, both genetically and culturally (Whaley 1997: 53). Indeed, "in view of recent proposals which suggest still larger genetic groupings [cf. Dryer (1989) and his notion of large linguistic areas], resulting in fewer independent language families, it is clear that it will become increasingly difficult to design representative probability samples in which languages are not genetically related" (Rijkhoff et al. 1993: 171)[17]. The sampling procedure used in this paper directly relates to this problem; it looks for languages with maximal genetic diversity.

The Diversity Value (DV) method thus controls for genetic bias. Underlying is the belief that if languages are closely related in time, they also tend to be closely related in typology, space and culture (Song 2001: 34). The DV method is designed to reveal underlying language structure, which is precisely what UPSID is after, namely the distribution of phonological segments in the world's languages. Two components assure maximal genetic diversity within samples: the first, minimal representation, accounts for

[16] Again, from a Laverian point of view, it is illogical to distinguish between pulmonic egressive stops and nasals. Nasal segments articulated "with complete oral closure" (Maddieson 1984: 166) are by definition stops. Remember that this thesis extends the traditional category of stops to include affricates, implosives, ejectives, clicks, nasals etc. The justification of this extension is given in section 1.

[17] Rijkhoff et al. (1993: 171) discern two kinds of language samples: *probability* samples exploit linguistic tendencies or correlations, while *variety* samples (like UPSID and PPRUPSID) identify "all possible realizations of a certain meaning or structure across languages".

variation *across* language families; the second, proportional representation, accounts for variation *within* language families.

Like UPSID's quota sample, the first component stipulates that, each language family or phylum must ideally have at least one representative in a sample, regardless of its size. Ruhlen (1987)[18] divides the world's languages into 17 language families, 9 Language Isolates (treated as singleton families[19]), 38 Pidgins and Creoles (treated as one artificial language family), and leaves 16 languages unclassified. Ignoring the latter, a total of 27 language families are recognized. This imposes a lower limit of 27 languages on the sample, which is shown in table 2.

Table 2: Phyla according to Ruhlen (1987)

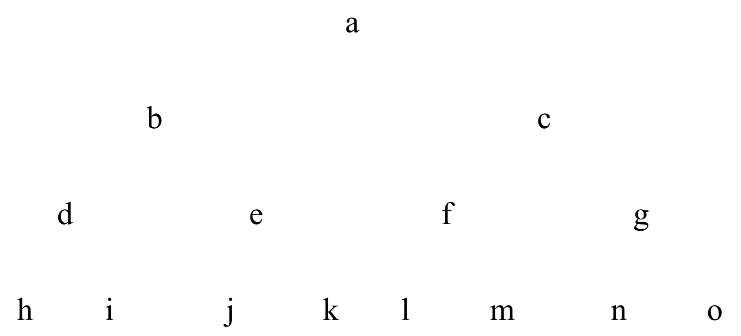
Phylum	extant	extinct	all
Afro-Asiatic	241	17	258
Altaic	63	3	66
Amerind	583	271	854
Australian	170	92	262
Austric	1175	11	1186
Caucasian	38	0	38
Chukchi-Kamchatkan	5	0	5
Elamo-Dravidian	28	1	29
Eskimo-Aleut	9	0	9
Indo-Hittite	144	36	180
Indo-Pacific	731	17	748
Khoisan	31	2	33
Na-Dene	34	7	41
Niger-Kordofanian	1064	4	1068
Nilo-Saharan	138	0	138
Sino-Tibetan	258	10	268
Uralic-Yukaghir	24	3	27
Language Isolates (x9)	5	4	9
Pidgins and Creoles	37	1	38
Unclassified lgs.	16	0	16
Totals	**4794**	**479**	**5273**

[18] I understand that Ruhlen's classification is not entirely uncontroversial (Rijkhoff et al. 1993: *fn*3), but Rijkhoff & Bakker (1998) illustrate that the DV method can also be applied to other genetic classifications.

[19] The singleton classification of the 9 Language Isolates is justified by their degree of typological peculiarity. Some argue that these languages are the sole survivors of now extinct families. See Comrie (1981: 238, 261) on Ket and Nichols (1990: 479) on Burushaski in this connection. Including all 9 Language Isolates would bias a sample geographically; the majority of these languages is or was spoken in Eurasia. However, this method favors genetic considerations over geographic ones (Rijkhoff et al. 1993: 179).

The second component applies when the sample size exceeds the 27-language minimum. When this is the case, the sample inevitably includes genetically related languages, i.e. from the same phylum. In this connection, Rijkhof et al. (1993: 176) state that "the number of languages in a sample that belong to the same phylum should be proportional to the linguistic diversity in that particular phylum." To live up to this goal of proportional representation, the relative weight of each language family is measured. Based on the depth and width of a phylum, the Diversity Value – a measure replacing Bell's age-criterion – gauges the diversity within each (sub)phylum, thereby determining the number of languages to be selected from that particular (sub)phylum.
Observing that the degree of linguistic variety in a phylum does not always correlate with the total number of languages in such a phylum, Rijkhof et al. (1993: 180) compute the DV "over the number of nodes at the intermediate levels between the top node of the tree and the terminal nodes at the bottom end". Since top nodes (e.g. *a* in figure 2) and terminal nodes (e.g. *h*, *i*, *j*, *k*, *l*, *m*, *n*, *o* in figure 2) do not add to internal diversity, they are excluded from computation. Only the intermediate nodes (*b*, *c*, *d*, *e*, *f*, *g* in figure 2) can be taken to measure diversity and hence form the data input for the computation of DVs, the exact procedure of which is extensively described in Rijkhoff (1992: 17-19), Rijkhoff et al. (1993:179-184), Bakker (1994: 85-91), Rijkhoff & Bakker (1998: 268-271), and in Song (2001: 35-37).
Since "a relatively small but well-chosen sample is in general to be preferred to a wealth of data" (Bakker 1994: 45), a sample size of 50 languages was chosen. For every phylum, table 3 lists the DV, the number of primary branches (PB), the total number of languages (lgs) and the number of sample languages to be selected from that phylum[20].

Figure 2: A hypothetical language family tree (after Song 2001: 35)



[20] For obvious reasons, no such data is given for the language isolates; their DVs are always 0.00, as singleton phyla they have no subphyla and, ideally, every language isolate is to be included in a sample. But since there are no adequate descriptions of Meriotic and Etruscan, the latter is practically impossible.

Now, the number of sample languages and the number of primary branches correlates: “if the former exceeds or equals the latter, it is possible to add more specifications with respect to the languages that are to be selected” (van Baar 1997: 10). For example, the sample requires five languages from the Austric phylum. This language family has three primary branches. At this time, the DV method is applied recursively. First, one language is selected from each primary branch in the Austric phylum (Austro-Tai, Austroasiatic and Miao-Yao). Then, the remaining languages are selected, proportional to their DVs. Since the DV of the Austro-Tai subphylum (106.03) outweighs the Austroasiatic and Miao-Yao DVs (28.08 and 2.00 respectively) by far, the three languages are to be selected from the Austro-Tai subphylum. Since this subphylum has two daughters, the method has to be applied once again. First, a language is selected from every daughter in the Austro-Tai subphylum (Austronesian and Daic). Then, the remaining two languages are selected randomly from the grouping with the highest DV, in this case Austronesian (118.17). The latter has four daughters (Malayo-Polynesian, Paiwanic, Tsouic and Atayalic) from which the remaining languages can ultimately be chosen. In this case, Tsouic and Atayalic languages have been sampled. This recursive application is also illustrated in table 3.

Table 3: A 50-language sample

Phylum	**DV**	**PB**	**lgs**	**sample**
Afro-Asiatic	55.53	6	258	2
Altaic	14.79	2	66	1
Amerind	178.44	6	854	7
Australian	67.58	30	262	3
Austric	137.14	3	1186	(5)
Austro-Tai	106.03	2	1027	(3)
Austronesian	118.17	4	970	(2)
Atayalic	0.00	0	2	1
Tsouic	2.45	2	4	1
Daic	4.67	2	57	1
Austroasiatic	28.08	2	155	1
Miao-Yao	2.00	2	4	1
Caucasian	8.54	2	38	1
Chukchi-Kamchatkan	2.47	2	5	1
Elamo-Dravidian	7.43	2	29	1
Eskimo-Aleut	3.34	2	9	1
Indo-Hittite	39.71	2	180	2
Indo-Pacific	124.79	12	784	5
Khoisan	6.97	3	33	1
Na-Dene	9.44	2	41	1

Niger-Kordofanian	90.38	2	1068	4
Nilo-Saharan	42.18	9	138	2
Pidgins and Creoles	13.47	13	38	1
Sino-Tibetan	38.52	2	268	2
Uralic-Yukaghir	4.93	2	27	1
Language Isolates:				
Basque				1
Burushaski				1
Etruscan				1
Gilyak				1
Hurrian				1
Ket				1
Meriotic				1
Nahali				1
Sumerian				1

Furthermore, it should be noted that, genetically, Amerindian has the highest number of representatives in the sample (7). The next highest representation is Austric and Indo-Pacific (5). Other phyla feature only one, two or three languages. It is also important to note that table 3 is an ideal sample serving as a point of departure for this data collection (Crevels 2000: 69). Practical limitations of time, money, availability, and description (Perkins 1989: 297) ultimately led to an actual sample of 44 languages.

Table 4 shows the languages in the actual PRUPSID sample, as distributed over Ruhlen's phyla (as indicated in table 2). For each phylum, the selected languages and their respective subphyla are listed. For a proper understanding, the actual choice of languages requires a number of further comments.

A non-random selection procedure was applied (Rijkhoff et al. 1993: 197, Hengeveld 1992: 18); in view of the problem of cross-linguistic comparability (cf. introduction) and for reasons of bibliographic convenience, an effort was made to select UPSID languages as much as possible, while taking Rijkhoff's (1992: 21-22) 50-language sample as an example. Initially, overlapping languages were checked for in Rijkhoff (1992) and Maddieson (1984). Fifteen such overlaps were found. Then, cognate languages were looked for, i.e. UPSID substitutes from the same subphylum (based on Ruhlen 1987). For example, in the Ge-Pano-Carib subphylum, Rijkhoff's Hishkaryana was substituted for Carib, which has an UPSID representative (coded as 807 S). In a next phase, languages from different subphyla were selected, while respecting the sample proportions and DVs. For example, the Almosan-Keresiouan subphylum was substituted for Hokan (Northern Amerind), and Mangarayi for Daly (Australian), after which languages from these groupings were chosen that are in the UPSID database. The substitutions of subphyla are justified since the number of languages to be selected from Northern Amerind and Australian, two and three languages respectively, does not exceed the number of Northern Amerind and Australian primary branches or subphyla, namely three and thirty. This brought the total number of languages in the sample to forty. Whenever UPSID replacements could not be found, substitutes in Rijkhoff (1992: 21-2) or in Ruhlen (1987)[21] were looked for.

Inclusion criteria were availability of qualitative descriptions on the one hand, and a reasonable geographic distribution on the other (see table 5). For reasons of bibliographic convenience Rijkhoff's Berbice Dutch Creole was retained in the PRUPSID sample. In the Indo-Pacific family, Alamblak (Sepik-Ramu) was chosen, Rijkhoff's Galela (West Papuan) and Monumbo

Table 4: Genetic distribution of PRUPSID sample languages

(sub)phylum		**language**
Afro-Asiatic	(2)	
Chadic	1	Hausa
Cushitic	1	Somali
Altaic	1	Korean
Amerind	(7)	
Central Amerind	1	Hopi
Ge-Pano-Carib	1	Carib
Northern Amerind	(2)	
Penutian	1	Nez Perce
Hokan	1	Karok
Equatorial-Tucanoan	1	Guarani
Chibchan-Paezan	1	Bribri
Andean	1	Quechua
Australian	(3)	
Daly	1	Malakmalak
Pama-Nyungan	1	Wik-Munkan
Nunggubuyu	1	Nunggubuyu
Austric	(5)	
Austro-Tai	(3)	
Austronesian	(2)	

[21] In cases of conflicting classifications, I favored Ruhlen's. For example, Maddieson classifies Araucanian as a Penutian language of Amerindian, while Ruhlen classifies it as an Andean language of Amerindian (as Araucanian or Mapudungu). Also, Maddieson classifies the Miao-Yao subphylum as Sino-Tibetan, while Ruhlen thinks it belongs to the Austric family. Finally, different names for the same language are ascribed to differences in primary sources between Maddieson (1984) and Rijkhoff (1992). Here too, I favored Rijkhoff or Ruhlen.

Tsouic	1	Tsou
Atayalic	1	Atayal
Daic	1	Standard Thai
Austroasiatic	1	Khmer
Miao-Yao	1	Yao
Basque (language isolate)	1	Basque
Burushaski (language isolate)	1	Burushaski
Caucasian	1	Kabardian
Chukchi-Kamchatkan	1	Chukchi
Elamo-Dravidian	1	Malayalam
Eskimo-Aleut	1	West Greenlandic
Gilyak (language isolate)	1	Gilyak
Indo-Hittite	(2)	
Indo-European	1	Modern Greek
Indo-Pacific	(5)	
Trans-New Guinea	1	Asmat
Sepik Ramu	1	Alamblak
West Papuan	1	Maybrat
Torricelli	1	Bukiyip
East Papuan	1	Nasioi
Ket (language isolate)	1	Ket
Khoisan	1	Nama
Na-Dene	1	Haida
Niger-Kordofanian	(4)	
Niger-Congo	(3)	
Niger-Congo Proper	(2)	
Central Niger-Congo	1	Igbo
West Altantic	1	Wolof
Mande	1	Kpelle
Kordofanian	1	Moro
Nilo-Saharan	(2)	
East Sudanic	1	Maasai
Central Sudanic	1	Logbara
Pidgins and Creoles	1	Berbice Dutch Creole
Sino-Tibetan	(2)	
Sinitic	1	Mandarin Chinese
Tibeto-Karen	1	Burmese
Uralic-Yukaghir	1	Hungarian

(Torricelli) were replaced with Maybrat (West Papuan) and Bukiyip (Torricelli) respectively[22].

[22] For the sake of completeness, Rijkhoff (1992: 20, *fn*14) speaks of "a more refined method" which selects, respectively, 5 (and not 6) languages from the Austric phylum and (2 and not 1) languages from the Sino-Tibetan phylum. Consequently, I deleted Boumaa Fijan from the

In keeping with UPSID's sample of natural and extant languages, the extinct language isolates Etruscan, Hurrian, Meroitic, Sumerian were excluded from the sample, as was Hittite, a now extinct Anatolian language of the Indo-Hittite superfamily. Also, too little is known about the phonetics and phonology of Nahali, another language isolate, to allow for its inclusion in the PRUPSID sample. There are some 'Remarks on Nahali phonology' in Kuiper (1962: 16-9), but unfortunately "[o]wing to the deficiency of the data available it is impossible to give even a rough sketch of the phonemic system" (Kuiper 1962: 19). The Nahali entry in the *Linguistic Survey of India* has nothing on phonology, it only has notes on grammar, but even those "do not make any pretension to completeness". (Grierson 1966: 185). Thus, an ideal 50-language sample corresponds to an actual 44-language sample in this study; five extinct languages were excluded, while a sixth was not included due to a lack of adequate data. Note that the vacancies created by these six languages are not assigned to other languages, since this would distort the sample proportions (Rijkhoff et al 1993: 191).

Turning to areal stratification, the sample composition is relatively uniform. Table 5 shows the areal distribution of the sampled languages in terms of the six macro-areas that Dryer (1991) proposes, i.e. Eurasia, Africa, South-East Asia & Oceania, Australia & New Guinea, North America and South America[23]. Table 5 suggests that nearly a quarter (23%) of the PRUPSID languages are spoken in Africa. Two fifths are spoken in Eurasia (20%) and in South-East Asia & Oceania (20%). Australia & New Guinea occupies another 16%, while the rest is taken up by North (10%) and South America (11%).

Table 5: Areal distribution of the sample languages

Eurasia	Africa	SEA & Oc	Aus & NG	Namer	SAmer
9 ➔ 20%	10 ➔ 23%	9 ➔ 20%	7 ➔ 16%	4 ➔ 10%	5 ➔ 11%

Malayo-Polynesian subphylum of Austric and added Burmese (509 S) from the Tibeto-Karen subphylum of Sino-Tibetan.

[23] These areal distinctions are based on the degree of typological diversity. In a previous article, Dryer (1989: 269) recognizes only five macro-areas (Eurasia, Africa, Australia & New Guinea, North America and South America), thus leaving out the South-East Asia & Oceania area, but he admits, "the particular choice of areas remains tentative".

Table 6 is a rough geographical outline of the sample languages, in alphabetical order[24]. Reference is made to either a primary source or to a three-digit language identification code as used in UPSID (Maddieson 1984: 164). The inclusion of 'S' in the identification code implies that the phoneme inventory of a particular language was partly derived from information in the Stanford Phonology Archive. Coincidentally, all but three languages have an 'S'. For a bibliography of the coded languages, please turn to Maddieson (1984: 177-199). Four languages were not in UPSID: Alamblak, Bukiyip, Berbice Dutch Creole and Maybrat. Author and date identify the sources used for these languages. Complete bibliography can be found in the list of references. Note that there are four languages in the sample that are spoken in the Papua New Guinea area (Alamblak, Asmat, Bukiyip and Nasioi). This geographic consideration is overruled by the genetic criterion, which has absolute precedence in this method of language sampling.

Out of the 44-language sample, all but four phoneme inventories are based entirely on the information in UPSID. Although it is not always clear what language variants, i.e. dialects have been sampled, Maddieson's consistency and uniformity in his inventories sets an impressive standard, one the present author has not been able to equal. The phoneme inventories of the remaining four languages, Alamblak, Bukiyip, Maybrat and Berbice Dutch Creole have been taken and adapted from reference works (cf. table 6). Phoneme charts for the other languages can be found in Maddieson (1984: 263-422). In comparison with UPSID, the data on these four languages is inferior, both quantitatively and qualitatively. As for the quantity, a single source of data per language was used; as for the quality, it was assumed that the segmental inventories in these sources were exhaustive and final. This assumption may have (over)simplified decisions on inclusion or exclusion. More precisely, it was assumed that these inventories specified the exact number of phonologically contrastive units and that the consonantal segments in these inventories represented their "most characteristic allophone". Furthermore, the phonetic properties assigned to each segment were taken for granted.

Table 6: Approximate location of sample languages

Language (primary source)	**Approximate location**
Alamblak (Bruce 1984)	Papua New Guinea (East Sepik Province)
Asmat (601 S)	Papua New Guinea (coast of Casuarina; Irian Jaya)

[24] The information in table 6 is based on Rijkhoff (1992: 23-4), Laver (1994: 596-621) and Ludo Lejeune's (Center for Grammar, Cognition and Typology researcher [CGCT], UIA) electronic *Language Sources Database* at: http://pcger50.uia.ac.be/Cgct/Lang_request3.html.

Atayal (407 S)	Philippines
Basque (914 S)	NE Spain, SE France (both sides of W Pyrenees)
Berbice Dutch Creole (Kouwenberg1994)	Guyana
Bukiyip (Conrad & Wogiga 1991)	Papua New Guinea (Torricelli mountains)
Burmese (509 S)	Burma, Malaysia, Thailand,…
Burushaski (915 S)	Pakistan
Bribri (801 S)	Panama, Costa Rica
Carib (807 S)	Surinam Guyana, Brazil, …
Chukchi (908 S)	Russia, NE Siberia, Chukchi Peninsula
Gilyak (909 S)	Russia, Amur River, Sakhalin Island
Greek, Modern (000 S)	Greece
Greenlandic, West (900 S)	Greenland, Denmark
Guarani (828 S)	Paraguay, Argentina, Bolivia, Brazil
Haida (700 S)	Canada, Alaskan panhandle
Hausa (266 S)	Nigeria, Togo, Benin, …(West Africa)
Hopi (738 S)	NE Arizona, Utah, New Mexico
Hungarian (054 S)	Hungary
Igbo (116 S)	Nigeria
Kabardian (911 S)	NW Caucasus
Karok (741 S)	NW California
Ket (906 S)	Russia, Siberia, Yenisey river area
Khmer (306 S)	Cambodia, Thailand, Vietnam
Korean (070 S)	Korea
Kpelle (103 S)	Guinea; SE of Liberian border
Logbara (215 S)	Uganda, Zaire
Maasai (204 S)	Kenya, Tanzania
Malakmalak (356)	Australia (Daly river area)
Malayalam (905)	India (Kerala, Laccadive Islands, …)
Mandarin Chinese (500 S)	China
Maybrat (Dol 1999)	Indonesia (Irian Jaya)
Moro (101)	N Sudan, E Nuba mountains, …
Nama (913 S)	Namibia, South Africa
Nasioi (624 S)	Papua New Guinea (North Solomons province)
Nez Perce (706 S)	USA (N Idaho)
Nunggubuyu (353 S)	Australia (Northern Territory)
Quechua (819 S)	Peru (Southwestern Ayacucho region)
Somali (258 S)	Somalia, Ethiopia, Kenya, Djibouti
Thai, Standard (400 S)	Thailand
Tsou (418)	Taiwan (Mount Ali area)
Wik-Munkan (358 S)	Australia (Edward River, Aurukun)
Wolof (107 S)	Africa (Senegal, Mauretania, Gambia)
Yao (517 S)	Africa (Malawi, Tanzania, Mozambique)

In keeping with UPSID, every segment is binarily coded with reference to a list of phonetic attributes, the result of which is the description of the segment at hand. Since these variables "are in all cases either directly equivalent to or readily translatable into the phonetic dimensions" (Laver 1994: 578) outlined in *Principles of phonetics*, this section presents an overview of such a translation. The phonetic specifications are thus derived from Laverian linguistic phonetic theory, but they are modeled after Maddieson (1984: 163-170). Logically, applying the full descriptive power of Laverian theory is impossible, because PRUPSID recycles forty UPSID inventories in its 44-language sample. For example, Laver's label for a linguolabial displaced articulation is pointless here, because it is not distinguished in UPSID. The only displaced articulation UPSID recognizes is labiodental. Conversely, but for the same reason, Maddieson's (1984: 170) anomaly variable is retained in PRUPSID. This variable was designed to mark segments that merit inclusion despite their marginal status in an inventory. Note that this variable illustrates UPSID's thoroughness in determining the phoneme inventories. The 44 variables are described in Appendix A.

3. Results

Section 3.1 surveys the overall results concerning stop inventory size – the number of phonologically contrastive stop segments a language may have – and structure – as gauged by a hypothetical stop inventory. These first results suggest two fundamental questions. Firstly, how do the proportions of stop articulations vary in relation to inventory size? And secondly, how do languages select stops? The first question is addressed in 3.2, the second in 3.3. Finally, 3.4 recapitulates the phonetic factors underlying stop inventory size and structure.

3.1 Inventory size and structure

The number of contrastive stop segments per language varies widely. PRUPSID's smallest inventories have only 6 and 7 stop segments (Maybrat and Asmat respectively), while the largest inventories have 33 such segments (Haida and Igbo). If we leave out these extremes, the mean number of stop segments per language is a little under 15 (669 – 79 / 40 = 14.75), if we leave them in, the mean number is a little over 15 (669 / 44 = 15.20); the median falls between 15 and 16. However, the 'typical' stop inventory has between 8 and 21 segments – 82% of PRUPSID languages fall within these limits[25].

[25] In UPSID, the 'typical' phoneme inventory has a range of 20 to 37 segments (70% of UPSID languages comply). Maddieson (1984: 7) points out that we shouldn't consider this range to be 'optimal'; languages with unusually small (e.g. Polynesian languages) or large inventories (e.g.

A PRUPSID segment index revealed a total of 669 stop segments. Table 7 shows the distribution of stop segments with respect to aspects of articulation, initiation and coordination. In terms of the conformational aspect of articulation, PRUPSID has 328 stops with an oral aspect and 159 stops with a nasal aspect. Moving to airstream initiation, PRUPSID has 36 glottalic segments (24 ejectives and 12 implosives) and 20 velaric segments (10 regular clicks and 10 affricated clicks). With respect to coordination, PRUPSID has 83 affricates (including 4 ejective affricates). Finally, PRUPSID has 43 segments with a transitional aspect of articulation: 16 trills, 20 flaps and 2 taps and 5 unspecified r-sounds.

Table 7: Distribution of stop segments over aspects of articulation, initiation and coordination

Category	Number (+ percentages)
Conformational aspect:	
1. oral stops	328 (49.03%)
2. nasal stops	159 (23.77%)
Initiation:	
3. glottalic stops (ejectives and implosives)	36 (= 24 + 12) (3.59% + 1.79%=5.38%)
4. velaric stops (clicks, including affricated clicks)	20 (= 10 + 10) (1.49% + 1.49%=2.98%)
Coordination:	
5. affricated stops (including ejective affricates)	83 (= 79 + 4) (11.81% + 0.60%=12.41%)
Transitional aspect:	
6. trilled, tapped and flapped stops (including unspecified r-sounds)	43 (= 16 + 2 + 20 + 5 unspec.) (2.39% + 0.30% + 2.99% + 0.75%=6.43%)

Based on the results in table 7, predictions can be made about the structure of a hypothetical stop inventory, thus claiming a relationship between stop inventory size

Khoisan languages) have stood the test of time. We have no evidence of languages having expanded or contracted towards a 'typical' inventory size. Presumed principles of dysfunction in a small inventory – lack of contrastive morphemes, resulting in high incidence of homophony or extremely lengthy morphemes – or in a large inventory – redundant morphemes, resulting in discriminatory confusion – do not seem applicable (Pagliuca & Perkins 1986: 366).

and structure. It can be expected that a prototypical stop inventory consists of about 75% oral and nasal stops. The remaining quarter is made up of affricates (12%), trills, taps and flaps (7%), and lastly, glottalic and velaric stops (6%)[26]. This prediction can be verified by measuring which stops have the highest frequency of occurrence in PRUPSID's segment index. Table 8 illustrates such an inventory.

Table 8: A prototypical stop inventory

p	*t	tS	k
m	*n		N
b	*d		g
	*r		

Assuming relative similarity of place of articulation, the dental, dental/alveolar and alveolar segments /*t, *d, *n, *r / are marked with an asterisk. Note that /*r / represents trilled, flapped, tapped and unspecified r-sounds. Values for other stop segments are noticeably lower. The above stop inventory has the following characteristics:

- all segments are all place-neutral.
- in terms of frequency of occurrence, voiceless oral stops are roughly equally frequent as voiced nasal stops, followed by voiced oral stops and finally trilled stops.
- the nasal aspect is introduced in the stop system before oral stop voicing is (e.g. / m / 97% versus / b / 55%).
- voiced nasal stops are more frequent than voiced oral stops (e.g. /*n/ 97% versus /*d/ 49%).
- the most frequent place of articulation is (dental/)alveolar.

Overall, the inventory in table 8 roughly confirms the prediction made about inventory structure; the majority of segments are oral and nasal stops, while the rest are affricates and r-sounds. Furthermore, this suggests a relationship between inventory size and structure. According to Maddieson (1984: 11), this relationship "is a matter that concerns individual types of segments, rather than being amenable to broad generalizations." Drawing on Lindblom & Maddieson (1988), the following explores this relation with respect to stop segments. Based on the abovementioned results, it is

[26] It is not surprising that ejectives, implosives and clicks are infrequent segments. The pulmonic egressive airstream is by far the most commonly used mechanism in languages of the world (Laver 1994: 161).

assumed that the proportions of stop articulations vary as a function of inventory size and that languages select stops hierarchically.

3.2 Proportions of stop articulations

In their article, Lindblom & Maddieson (1988) observe that languages tend to use 70% obstruents and 30% sonorants[27]. They ascribe this ratio to vocal tract physiology[28], more specifically to the phonetic space that obstruents and sonorants occupy – the obstruent space is larger and richer than that of sonorants. The 'phonetic space' of the human vocal tract is determined largely by language-independent biological constraints. Consequently, it can be expected that the proportions of obstruents and sonorants are relatively constant and independent of consonant-inventory size as well as areal and historical factors. As such, Lindblom & Maddieson (1988: 66) "feel justified in suggesting that [the obstruent/sonorant ratio] reflects a *phonetic universal*."

Following this train of thought, this section examines the proportions of stop obstruents and sonorants cross-linguistically, areally and historically. For the sake of clarity, stop obstruents consist of oral stops, implosive and ejective stops, clicks and affricates; stop sonorants consist of nasal stops, taps, flaps, trills and unspecified r-sounds.

3.2.1 Cross-linguistic proportions

PRUPSID's segment index allows for a quick assessment of the cross-linguistic stop obstruent-sonorant proportions. The percentages are given in table 9.

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[27] Lindblom & Maddieson (1988: 64) arrived at this ratio by plotting "the number of obstruents against total system size for each language in the UPSID database". They found that the number of obstruents in a given language accounts for roughly two-thirds or three-quarters of the total number of consonants in that language, thereby implying that sonorants take up the remaining one-third or one-quarter of the consonant inventory. For the record, obstruents are characterized phonetically "by obvious […] obstacles along the vocal tract, in the form of either a complete blockage of the acoustic channel (stops) or constrictions causing generation of turbulent noise (fricatives), or a temporally sequential combination thereof (affricates)" (Fujimura & Erickson 1997: 73). In the case of sonorants, "the vocal tract leaves a wide enough channel for the [air to flow] through the main vocal tract, whether it is a midsagittal passage or lateral passage [taps, flaps, trills, approximants], or through the nasal passages [for nasal segments], so that the vocal fold vibration is easily maintained" (Fujimura & Erickson 1997: 77). In short, sonorants allow air to flow freely between the upper larynx and the outer air (Boersma 1998: 288). Logically, stop obstruents and sonorants exclude fricative segments and approximants. Strictly speaking, Laverian theory collapses the stop obstruent/sonorant distinction, as the category of stops includes both sonorants (tapped, flapped, trilled stops and nasal stops), as well as obstruents (oral stops, implosive and ejective stops, clicks, affricates, ejective affricates, and affricated clicks). For reasons of practical convenience however, the obstruent/sonorant distinction is applied in this section.

[28] They thus favor an 'ecological' approach to phonetic universals, i.e. one that pertains to physiological, aerodynamic and perceptual factors in light of the principle of language functionality (Maddieson 1997: 634).

Table 9: Cross-linguistic stop obstruent-sonorant proportions

Obstruents	**%**	**Sonorants**	**%**
oral stops	49.02	nasal stops	23.77
implosive stop	1.79	tap	0.30
ejective stop	3.59	flap	2.99
click	1.49	trill	2.39
affricate	11.80	unspecified r-sound	0.75
ejective affricate	0.59		
affricated click	1.49		
Totals	69.77%		30.2%

It is quite clear that the results in table 9 conform to the posited phonetic universal of stop obstruent-sonorant proportions.

3.2.2 Areal proportions

It is interesting to plot the stop obstruent-sonorant proportions against Dryer's (1991) six macro-areas. These areas are: Eurasia, Africa, South-East Asia & Oceania, Australia & New Guinea, North America and South America. Table 10 summarizes the results. Areally, the proportion also checks out; the average ratio of the six macro-areas is 68.06% – 31.93%. The Australian & New Guinea area strays somewhat from the 70-30 proportion: 56.33% - 43.67%. We know relatively little about the highly diverse Pacific languages (Lynch 1998, Crystal 1997: 319).

Table 10: Stop obstruent-sonorant percentages over Dryer's (1991) macro-areas

Eurasia	74.63 – 25.36
Africa	74.62 – 25.38
SEA & Oc	67.2 – 32.8

Aus & NG	56.33 – 43.67
NAmer	70 - 30
Samer	65.62 – 34.38

The PRUPSID survey has 7 Pacific languages: Alamblak, Asmat, Bukiyip, Malakmalak, Nasioi, Nunggubuyu and Wik-Munkan. Sampling additional Pacific languages may push the ratio more towards the proposed 70-30 proportions.

3.2.3 Historical proportions

Historical proportions can be derived from genetic classifications, which are historical in that they assume that "languages have diverged from a common ancestor" (Crystal 1997: 295) and that they try to map the historical evolution of the parent language. Table 11 plots the stop obstruent-sonorant proportions against Rulhen's (1987) genetic classification.

Table 11: Stop obstruent-sonorant proportions over Rulhen's (1987) language families

Family	Languages	Percentage
Afro-Asiatic	Hausa, Somali	77.5 – 22.5
*Altaic	Korean	80 – 20
Amerind	Hopi, Carib, Nez Perce, Karok, Guarani, Bribri, Quechua	63.06 -36.98
*Australian	Malakmalak, Wik-Munkan, Nunggubuyu, Tsou, Atayal,	52.94 – 47.06
Austric	Khmer, Yao, Standard Thai	69.1 – 30.91
*Caucasian	Kabardian	87.51 – 12.5
Chukchi-Kamchatkan	Chukchi	66.66 – 33.33
Elamo-Dravidian	Malayalam	55.54 – 44.45
Eskimo-Aleut	West Greenlandic	62.5 – 37.5
Indo-Hittite	Modern Greek	72.73 – 27.27
Indo-Pacific	Asmat, Alamblak, Maybrat, Bukiyip, Nasioi	62.22 – 37.86
*Khoisan	Nama	89.45 – 10.15
*Na-Dene	Haida	81.81 – 18.18
Niger-Kordofanian	Igbo, Wolof, Kpelle, Moro	72.72 – 27.27
Nilo-Saharan	Maasai, Logbara	67.76 – 35.25
Pidgins and Creoles	Berbice Dutch Creole	66.66 – 33.33
Sino-Tibetan	Mandarin Chinese, Burmese	69.44 – 30.6
Uralic-Yukaghir	Hungarian	75 – 25
Language isolates	Basque, Burushaski, Gilyak, Ket	72.85 – 27.15

Historically, the average historical proportion is 70.81% – 29.33%. The excess 0.14% is the result of rounding. Despite this result, it is important to note that the language families marked by an asterisk differ considerably from the proposed 70%-30% ratio. Undersampling may explain these differences. In order to gauge the stop obstruent-sonorant ratios of these deviant language families, additional languages have been sampled. Additional UPSID languages were included. The following gives an overview of the additions.

- Altaic

The Altaic phylum has one representative in PRUPSID, Korean, which has an 80% – 20% ratio. In UPSID, the Ural-Altaic language family corresponds with PRUPSID's Uralic-Yukaghir and Altaic language families. Consequently, four additional languages from these two families were randomly selected, taking their DVs into account. The additional languages are: Azerbaijani, Japanese, Manchu (Altaic) and Finnish (Uralic-Yukaghir). If these additional languages are analysed in combination with Korean, the deviation disappears. The Altaic phylum has a 72.22% – 27.78% ratio.

- Australian

The stop obstruent-sonorant ratio of the Australian phylum is 52.94% – 47.06%. Three Australian languages were added: Burera, Tiwi and Bandjalang. Surprisingly enough, the additions lower the ratio to 50% – 50%. There were no good data needed for additional counterscreening. The deviant ratio of Australian is ironed out by the average language family ratio.

A. Caucasian

The sole Caucasian representative Kabardian in PRUPSID has an 87.51% – 12.5% proportion. The only additional Caucasian language in UPSID was Georgian. The addition of the latter brought the ratio to 86.05% – 13.95%.

A. Elamo-Dravidian

Malayalam has a 55.54% – 44.45% ratio. After adding two languages from the same phylum (Kota and Brahui), the proportion becomes far less deviant: 64.7% – 35.29%.

A. Khoisan

The typological peculiarity of Khoisan languages is well known. The abundance of click segments in this phylum distorts the 'normal' proportions. As can be expected, the

89.45% – 10.15% ratio of Nama is a far cry from the proposed 70% – 30% ratio. No other Khoisan languages were added, as this would only further distort the ratio.

- Na-Dene

Na-Dene has one representative PRUPSID: Haida, a language with an 81.81% – 18.18% proportion. Addition of Tlingit brought the ratio to 86.05% – 13.95%.

In sum, the above results support the hypothesis of a phonetic universal pertaining to the proportions of stop articulations. It was shown that the 70% – 30% ratio of stop obstruents-sonorants applies cross-linguistically, areally and historically. Deviations from this proportion are resolved by the ratio averages, or can be explained by their degree of phonological peculiarity.

3.3 Selection of stop articulations

Lindblom & Maddieson (1988: 67) divide consonantal segments into three sets (basic, elaborated and complex segments) over a scale of increasing articulatory complexity. Basic articulations (set I) are characterized by a default phonation and articulation. Examples are place neutral voiced and voiceless pulmonic egressive segments. Voiceless affricates are also considered basic articulations. Elaborated articulations (set II) imply phonetic properties such as breathy, creaky voiced; voiced affricates; devoicing; pre- and post-nasalization; aspiration; ejectives; implosives; clicks; labiodental, palato-alveolar, uvular and pharyngeal articulations; retroflex and secondary articulations. Complex articulations (set III), finally, are combinatioins of the former category, e.g. a breathy voiced retroflex stop.

Focusing on stop segments, Set I produces the following stop inventory `/p,t,k,b,d,g,?,tS,m,n,N,*r/`. This inventory equals the hypothetical stop inventory in table 8 exactly. Subsequently, it is assumed that this three-set scale of articulatory complexity governs this selection of stops. In other words, if stops are added to a small phonology, they will most likely be articulations of the basic type initially. Once the phonetic space is saturated with basic segments, elaborated segments are added, followed by complex articulations. This pattern can be easily verified; we can screen for stop inventories that reverse this pattern of expansion. Thus, we can look for stop systems that, when small, employ primarily Set III articulations; when large or medium also feature additional Set II stops segments; and when extra-large, also select Set I elements. Absence of such a pattern can then be taken as an indication of the robustness of the Set I > II > III continuum. Table 12 examines whether or not Ruhlen's 18 language families exhibit such a regular pattern.

Table 12: Set I, II and III stops plotted against Ruhlen's (1987) language families

Phyla	**Language**	**Set I > II > III**
Afro-Asiatic	Hausa, Somali	20 > 16 > 4
Altaic	Korean	9 > 6 > 0
Amerind	Hopi, Carib, *Nez Perce, Karok, Guarani, Bribri, *Quechua	62 > 30 > 0
Australian	Malakmalak, Wik-Munkan, Nunggubuyu, Tsou, Atayal,	47 > 4 > 0
Austroasiatic	Khmer, *Yao, Standard Thai	30 > 25 > 0
*Caucasian	*Kabardian	8 < 13 > 3
Chukchi-Kamchatkan	Chukchi	9 > 0 > 0
Elamo-Dravidian	Malayalam	12 > 6 > 0
Eskimo-Aleut	West Greenlandic	8 > 0 > 0
Indo-Hittite	Modern Greek	10 > 1 > 0
Indo-Pacific	Asmat, Alamblak, Maybrat, Bukiyip, Nasioi	42 > 3 > 0
*Khoisan	*Nama	7 < 3 < 19
*Na-Dene	*Haida	9 < 17 > 7
Niger-Kordofanian	*Igbo, Wolof, Kpelle, Moro	41 > 31 > 5
Nilo-Saharan	Maasai, Logbara	21 > 10 > 0
Pidgins and Creoles	Berbice Dutch Creole	9 > 0 > 0
*Sino-Tibetan	`*Mandarin Chinese, Burmese	18 = 18 > 0
Uralic-Yukaghir	Hungarian	11 > 5 > 0

Table 12 clearly indicates that the majority of phyla adhere to the Set I-III continuum, thus supplying evidence for the assumption that system growth correlates directly with articulatory complexity. Language phyla or individual languages marked with an asterisk reveal a slightly deviant pattern. For example, Haida has more elaborated stops than it does basic, while Nama showcases its degree of phonological peculiarity once again; it has more complex segments than it does basic and elaborated. Nevertheless, languages with a regular pattern outnumber those with an irregular pattern by far.

The apparent relation between inventory size and structure requires an attempt at explanation. Lindblom & Maddieson (1988: 71) ascribe system growth to "an alternating process of [phonetic] subspace *saturation* and local *expansion*". An example may clarify this process. Imagine a small inventory that could achieve sufficient contrast by /p,t,k/. If more segments have to be added, palatalization is but one option, resulting in /p,pJ,t,tJ,k,kJ/. From this, it can be seen that perceptual salience between say /p/ and /kJ/ increases. The important point to make here is that system growth along the scale of Set I to III implies an increase in articulatory complexity on the one hand, and expansion of the phonetic space available for perceptual contrast on the other. Stop inventories seem to make concerted efforts at reducing articulatory complexity as much as possible, while, simultaneously, maintaining sufficient perceptual salience, regardless of inventory size.

There seem to be universal phonetic conditions – relating to factors of production and perception – governing stop inventories. More precisely, stop inventory size and structure is the result of the interplay between articulatory economy – accounting for the frequency of occurrence of Set I stops – and perceptual salience – maintaining the functional notion of sufficient distinctiveness. Consequently, we can formulate the following generalization: "Stop inventories tend to evolve so as to achieve maximal perceptual distinctiveness at minimum articulatory cost". (After Lindblom & Maddieson 1988: 72). Generalizations like these lie at the heart of the linguistic phonetic endeavor. Once again, note how closely phonetics and phonology are connected in this perspective: the notions of phonetic distance and perceptual salience explain phonological structure phonetically.

4. Conclusion

Like Ohala, I believe that "the defining characteristics of a discipline are not its methods nor its theories - [i.e., T.V.H.] the answers to questions - but rather the questions themselves." (Ohala 1997: 674). This paper investigated what phonetic categories of stops are used in languages and how stop inventories can be explained phonetically.

The description and exploration of phonetic factors underlying the structure of phonological stop inventories was studied in a Laverian linguistic phonetic framework. The theoretical innovation of aspects of articulation procured the extension of the scope of traditional stop segments. Based on the applicability of conformational, topographical and transitional aspects of articulation, the PRUPSID stop category thus comprises oral and nasal pulmonic stops, ejective and implosive stops, clicks, double and secondary articulations, affricated stops, ejective affricates, affricated clicks, and lastly, tapped, flapped, and trilled stops.

The DV method of language sampling maximized genetic variety and diversity of the language data in question by computing a measure based on the internal structure of each language family. This remarkable measure was claimed to be applicable to any given sample size and determined the selection of the number of languages from each unique language tree. In principle, this kind of variety sample ideally draws from all known extinct and extant natural languages, but in keeping with UPSID, PRUPSID was limited to extant languages. As such, the sample meets Goyvaerts' (1975: 15) criteria of representativeness: it is non-arbitrary, exhaustive and unique. Consequently, the sample warrants observations about a genetically, typologically and areally stratified sample of languages, considered to be representative of the whole universe of human language.

The central hypothesis claims that phonetic factors ultimately govern the size and structure of stop inventories. Observing a functional-structural consistency of stop inventories, two phonetic universals have been proposed: as a function of inventory size, stop obstruent-sonorants display a ratio of 70% – 30%. As a function of inventory structure, stop inventories are selected along a three-set hierarchy of articulatory complexity.

The first universal was shown to apply cross-linguistically, areally and historically, the second was counterbalanced by the functional requirement of phonetic salience. Ultimately, biological and language-external human processing constraints invited an attempt at explanation. Stop inventories, regardless of their size, should contain only perceptually salient stops. During growth, more and more of the phonetic space is used until a point of saturation is reached, ultimately resulting in an increase of articulatory complexity. The size and structure of stop inventories is thus accounted for by universal phonetic conditions pertaining to proportion and selection.

References

- Abercrombie, D. (1972) *Elements of General Phonetics*. Edinburgh: Edinburgh University Press.
- Bakker, D. (1994) *Formal and computational aspects of functional grammar and language typology.* Doctoral Dissertation. University of Amsterdam (UvA: IFOTT).
- Bell, A. (1978) 'Language samples' IN: Greenberg, J. H. (ed.) *Universals of human language. Volume 1: Method and theory*, Stanford: Stanford University Press, 123-156.
- Boersma, P. P. G. (1998) Functional Phonology. Formalizing the interactions between articulatory and perceptual drives. Doctoral dissertation. University of Amsterdam (UvA/IFOTT).
- Bruce, L. (1984) *The Alamblak Language of Papua New Guinea (East Sepik)*. Canberra: Australian National University (= Pacific Linguistics C-81).
- Bybee, J. (1985) *Morphology. A Study of the Relation between Meaning and Form*. Amsterdam: John Benjamins.
- Catford, J.C. (1977) *Fundamental problems in Phonetics*. Edinburgh: Edinburgh University Press.
- Comrie, B. (1978) 'Linguistics is about languages'. *Studies in the Linguistic Sciences*, 8 (2), 221-236.

- Conrad, R. J. & K. Wogiga (1991) *An outline of Bukiyip grammar*. Canberrra: Australian National University (= Pacific Linguistics C-3).
- Crevels, E. I. (2000) *Concession. A typological study*. Doctoral Dissertation. University of Amsterdam (UvA).
- Croft, W. (1990) *Typology and Universals*. Cambridge: Cambridge University Press.
- Crystal, D. (1997) *The Encyclopedia of Language* (2nd ed.). Cambridge: Cambridge University Press.
- Diehl, R.L. (1991) ‘The role of phonetics in the study of language.’ In: *Phonetica*, 48, 120-134.
- Dol, P. H. (1999) *A grammar of Maybrat. A language of the Bird’s Head, Irian Jaya, Indonesia*. Doctoral dissertation. University of Leiden.
- Dryer, M. S. (1989) ‘Large linguistic areas and language sampling’. *Studies in Language*, 13 (2), 257-292.
- Dryer, M. S. (1991) ‘SVO languages and the OV:VO typology’. *Journal of Linguistics* 27: 443-82.
- Fujimura, O. & D. Erickson (1997) ‘Acoustic Phonetics’ IN: Hardcastle, W.J. & J. Laver (eds.) *The Handbook of Phonetic Sciences*. Oxford: Blackwell, 65-115.
- Goyvaerts, D. L. (1975) *Present-Day Historical and Comparative Linguistics. An Introductory Guide to Theory and Method. Part I: General Background and Phonological Change*. Ghent: E. Story-Scientia.
- Grierson, G. A. (1966) *Linguistic Survey of India. Vol. IV. Munda and Dravidian Languages*. Dehli: Motilal Banarsidass.
- Hengeveld, K. (1992) *Non-verbal Predication. Theory, Typology, Diachrony*. Berlin: Mouton de Gruyter.
- Ingemann, F. (1997) Review of ‘**Principles of phonetics’**. By John Laver. Cambridge: Cambridge University Press, 1994. Pp. xxviii, 707.’ *Language*, 73 (1), 172-175.
- Jones, D. (1967) ‘Explanations’ In: Jones, D. *Everyman’s English Pronouncing Dictionary. Containing over 58,000 words in International Phonetic Transcription*. London: J.M. Dent & Sons, xxii-xliv.
- Kouwenberg, S. (1994) *A grammar of Berbic Dutch Creole*. Berlin: Mouton de Gruyter.
- Kuiper, F. B. J. (1962) *Nahali: a comparative study*. Amsterdam: Noord-Hollandse Uitgevers (Mededelingen der Koninklijke Nederlandse Akademie van Wetenschappen, Afd. Letterkunde, Deel 25, No. 5)
- Ladefoged, P. (1971) *Preliminaries to linguistic phonetics*. Chicago: University of Chicago Press.

- Ladefoged, P. (1975) *A course in phonetics*. New York: Harcourt Brace Jovanovich.
- Ladefoged, P. (1997) 'Linguistic Phonetic Descriptions' IN: Hardcastle, W. J. & J. Laver (eds.) *The Handbook of Phonetic Sciences*. Oxford: Blackwell, 589-618.
- Ladefoged, P. and I. Maddieson (1996), *The Sounds of the World's Languages*. Oxford: Blackwell.
- Laver, J. (1994) *Principles of phonetics*. Cambridge: Cambridge University Press.
- Laver, J. (2001) 'Linguistic Phonetics' IN: Aronoff, M. & J. Rees-Miller (eds.) *The Handbook of Linguistics*. Oxford: Blackwell, 150-179.
- Lindblom, B., P. MacNeilage & M. Studdert-Kennedy (1984) 'Self-organizing processes and the explanation of phonological universals'. IN: Butterworth, B., B. Comrie & Ö. Dahl (eds.) *Explanations for Language Universals*. Berlin: Mouton, 181-203.
- Lindblom, B. & I. Maddieson (1988) 'Phonetic Universals in Consonant Systems' IN: Hyman, L. M. & C. N. Li (eds.) *Language, Speech and Mind. Studies in Honour of Victoria A. Fromkin*. London: Routledge, 62-78.
- Lock, A. & C.R. Peters (eds.) (1999) *Handbook of Human Symbolic Evolution*. Oxford: Blackwell.
- Lynch, J. (1998) *Pacific Languages. An Introduction*. Honolulu: University of Hawai'i Press.
- Lyons, J. (1987) 'Introduction.' In: Lyons, J., R. Coates, M. Deuchar & G. Gazdar (eds.) *New Horizons in Linguistics 2*. Harmondsworth: Penguin Books, 1-29.
- Maddieson, I. (1984) *Patterns of sounds*. Cambridge: Cambridge University Press.
- Maddieson, I. (1997) 'Phonetic Universals' IN: Hardcastle, W. J. & J. Laver (eds.) *The Handbook of Phonetic Sciences*. Oxford: Blackwell, 619-639.
- Maddieson, I. & K. Precoda (1989) 'Updating UPSID'. *Journal of the Acoustical Society of America*, Suppl. 1, Vol. 86, S19.
- Nichols, J. (1990) 'Linguistic diversity and the first settlement of the New World'. *Language*, 66 (3), 475-521.
- Ohala, J.J. (1997) 'The Relation Between Phonetics and Phonology' In: Hardcastle, W.J. & J. Laver (eds.) *The Handbook of Phonetic Sciences*. Oxford: Blackwell, 674-694.
- Pagliuca, W. & R. D. Perkins (1986) 'Review of: *Patterns of sounds*, by Ian Maddieson, with a chapter contributed by Sandra F. Disner (Cambridge University Press, 1984)'. *Lingua*, 70, 365-75.
- Perkins, R. D. (1989) 'Statistical techniques for determining language sample size'. *Studies in Language*, 13 (2), 293-315.

- Rijkhoff, J. N. M. (1992) *The noun phrase. A typological study of its form and structure*. Doctoral dissertation. University of Amsterdam (UvA: IFOTT).
- Rijkhoff, J., D. Bakker, K. Hengeveld & P. Kahrel (1993) 'A method of language sampling'. *Studies in Language*, 17 (1), 169-203.
- Rijkhoff, J. & D. Bakker (1998) 'Language sampling'. *Linguistic Typology*, 2 (3), 263-314.
- Ruhlen (1987) *A guide to the world's languages. Vol. 1: Classification.* London: Edward Arnold.
- Song, J. J. (2001) *Linguistic Typology: Morphology and Syntax*. London: Longman
- Stevens, K. & S. J. Keyser (1989) 'Primary features and their enhancement in consonants'. *Language*, 65 (1), 81-106.
- van Baar, T. M. (1997) *Phasal polarity*. Doctoral Dissertation. University of Amsterdam (UvA: IFOTT).
- Verhoeven, J. (forthcoming) *New Perspectives in General Phonetic Theory*.
- Whaley, L. J. (1997) *Introduction to typology. The unity and diversity of language*. Thousand Oaks: Sage.

Appendix A: description of PRUPSID phonetic variables.

The variables described in what follows form the horizontal part of the PRUPSID coding matrix. Vertically, the name of the language plus the IPA symbol for the given segment is listed. In total, 44 phonetic parameters apply in the description of PRUPSID stop segments. They are divided over the five components of (inter)segmental speech production: initiation, phonation, articulation, co-ordination and duration. Comments on these variables are given where necessary.

Initiation variables[29]

1. Pulmonic egressive stops.

   Note that these include oral, nasal, complex oral/nasal, glottal, tapped, flapped, trilled, aspirated and affricated stops; they all receive the value 1 for this variable. Strictly speaking, this variable can also be attributed to double and secondary stop articulations[30].

2. Velaric ingressive stops.

   Clicks receive the value 1 for this variable.

[29] Combined airstream mechanisms, such as voiced implosives and voiced clicks, are covered by the respective initiation and phonation variables.

[30] However, note that Laver (1994: 322) mentions contrastive use of labialization on uvular and velar ejective stops in Tabassaran and Thompson respectively, two languages of the Northwest Caucasus.

3. Glottalic egressive stops.
   Ejective stops have the value 1 here.
4. Glottalic ingressive stops.
   Implosives, whether or not voiced, receive the value 1 for this variable.

Phonation variables

5. Voiceless stops.
   Note that glottal stops are by definition voiceless (Laver 1994: 187-8).
6. Voiced stops.
   Voiced stops are attributed the value 1 here.
7. Creaky voiced stops.
   This variable concerns voiced laryngealized segments, a secondary articulation that is often associated with this mode of phonation (Laver 1994: 330). Voiced laryngealized stops receive an asterisk value 1, illustrating the position PRUPSID adopts in this matter. See also variable 32.
8. Breathy voiced stops.
   Note that voiced aspiration belongs here too; they both have the value 1 for this variable.

Articulation variables

Place of articulation: neutral

9. Labial.
10. Dental.
11. Unspecified dental/alveolar.
    This variable is included to prevent data falsification. Some sources are indeterminate between a dental and an alveolar place of articulation of, for example /t,d/. Note that unspecified dental or alveolar segments are marked with quotation marks, e.g. /“t”/, /“d”/. PRUPSID adopts this practice.
12. Alveolar.
13. Palato-alveolar.
    No distinction is drawn between palato-alveolar or alveolo-palatal place of articulation. Note that this place of articulation is, by default, assigned to retroflex stops.
14. Palatal.
15. Velar.
16. Uvular.
17. Pharyngeal.
18. Glottal. This place of articulation is reserved for glottal stops only.

Place of articulation: displaced

19. Labiodental

Note that this is the only displaced place of articulation that UPSID recognizes.

Degree of stricture

20. Stops

Again, the focus in this thesis is on segments characterized by a complete articulatory closure in the medial phase.

Aspect of articulation: conformational

Oral versus nasal

This is the theoretical construct that allows for the inclusion of nasal stops in the category of stops altogether. This position is in sharp contrast with Maddieson (1984: 165), who writes, “that nasals are not considered to be stops of any sort.” This conformational aspect has another descriptive advantage: it potentially captures the intricacies of complex oral/nasal stops. Depending on the interplay between oral or nasal onset and offset, four of these complex stops may emerge when “the feature of velic state is allowed to change its value within the medial phase of the segment concerned, asynchronously from the continuing oral closure” (Laver 1994: 227). They are pre-nasal oral stops, e.g. [^{m}b]; post-nasal oral stops, e.g. [b^{m}]; pre-occluded nasal stops, e.g. [^{b}m]; and post-occluded nasal stops, e.g. [m^{b}]. Note that affricates can also have the pre-nasal attribute. Maddieson (1984: 167) recognizes only pre-nasal oral stops and post-nasal oral stops. Pre- and post-occluded nasal stops are ignored in UPSID[31].

21. Oral stops

Remember that stops are assumed to have an oral aspect – the default value, unless specific mention is made of their nasal aspect of articulation. In the default setting, the oral aspect thus takes the value 1.

22. Nasal stops

This variable takes the value 1 for stops articulated with a nasal aspect of articulation.

[31] However, in *The Sounds of the World’s Languages* (Ladefoged & Maddieson 1996: 127-9), mention is made of contrastive use of pre- and post-occluded nasal stops. The authors prefer the terms pre- and post-stopped nasals though.

Complex oral stops

23. Pre-nasal oral stops.

Pre-nasal oral stops are classified in UPSID by the secondary articulation of nasalization. As a PRUPSID rule of thumb, whenever a pre-nasal stop presents itself, the conformational variable receives the value 1, while the secondary articulation variable is marked with an asterisk (*) value 1, illustrating the priority PRUPSID gives to the former variable.

24. Post-nasal oral stops.

In UPSID, post-nasal oral stops take the value 1 for a variable of nasal release. Again, in PRUPSID conformational variables take precedence over co-ordinatory variables as nasal release modes, which receive a value 1 with an asterisk.

Central versus lateral

Stops "are logically excluded from any choice between central versus lateral routing of the airflow since complete oral closure during the medial phase is a prerequisite for being classified as a stop segment" (Laver 1994: 211). PRUPSID nevertheless promotes the lateral aspect, because there are two types of stops that apply to this conformational aspect: lateral affricates, lateral clicks and lateral flaps. These articulations involve lateral release. They are thus the sole articulations that receive the value 1 for this variable. Consequently, the lateral plosion variable in the co-ordination component receives a value 1 with an asterisk.

25. Lateral

Lateral affricates, lateral clicks and lateral flaps are the only articulations that receive the value 1 for this variable.

Single versus multiple strictures

26. Single strictures.

In the default setting, which takes the value 1, stops have single strictures.

Multiple strictures

Multiple strictures occur in double and secondary articulations. Three double (labial alveolar, labial palatal, labial velar) and six secondary articulations (labialization, palatalization, velarization, pharyngealization, laryngealization and nasalization) are distinguished in PRUPSID. Location of constriction in double articulations is specified in the place-neutral component. Every secondary articulation has its separate variable though.

27. Double articulations

Note also that clicks are by definition double articulations; they are defined by a velar constriction and a constriction in the front part of the oral cavity (cf. Laver 1994: 175). So, clicks also receive the value 1 for this variable. Again, PRUPSID does not have separate entries that specify place of articulation; this location is identified in the place-neutral component.

Secondary articulations

28. Labialization.
29. Palatalization.
30. Velarization.
31. Pharyngealization.
32. Laryngealization.

Due to inconsistency of application in the source data, (PR)UPSID disregards such fine-grained distinctions as ‘pre-glottalized’ and ‘post-glottalized’ in its description of voiced laryngealized stops, a phenomenon that is usually associated with a ‘creaky voice’ phonation (Laver 1994: 330). As such, laryngealization (or glottalization as it is called in UPSID) can be classified as a phonation type (e.g. Maddieson 1984: 169) or as an articulatory phenomenon (e.g. Laver 1994: 330). PRUPSID thus adopts the latter position, which explains why voiced laryngealized segments receive the value 1 for this variable, and an asterisk value 1 for the creaky voice variable.

33. Nasalization.

Recall that this variable is also used to signal pre-nasal oral stops.

Aspect of articulation: topographical: longitudinal

34. Retroflexion

Like the IPA, UPSID classifies retroflexion as a place of articulation. But it is hard to pinpoint the exact place of articulation of retroflex segments. According to Laver (1994: 141), this place of articulation is at “some part of the palate”. By default, retroflexion is assigned a palato-alveolar place of articulation in PRUPSID. Observe how elegantly the aspects of articulation are able to avoid having to assign a place of articulation to retroflexion. Transverse topographical and other longitudinal aspects besides retroflexion (e.g. advancement of the tongue root, extension of the tongue tip…) do not apply to stops. Although not specifically identified in the matrix, note that retroflexion is a displaced articulation.

Aspect of articulation: transitional

35. Tapped stop.
36. Flapped stop.
37. Trilled stop.
38. Unspecified ‘r-sound’

    This variable takes the value 1 for segments which are vaguely described as some kind of ‘r-sound’ but which cannot be further specified as trill, tap or flap.

Co-ordination variables

39. Aspiration.

    This variable takes the value 1 for voiceless aspirated stops. Recall that voiced aspirates are classified as breathy voiced.
40. Affrication.

    Remember that this variable entails pulmonic egressive, glottalic egressive (ejective) and velaric ingressive (click) affricates.
41. Nasal release.

    In keeping with UPSID, this variable takes the value 1, albeit with an asterisk, for post-nasalized segments.
42. Lateral release.

    Lateral affricates, lateral clicks and lateral flaps are the sole recipients of the value 1 (with an asterisk) for this variable.

Duration variables

43. Long stops.

    This variable takes the value 1 for contrastively long stops (geminates).

The anomaly variable

44. Anomaly.

As mentioned above, the anomaly variable signals segments of marginal status in an inventory. This variable takes values anywhere between 0 and 5. A value of 0 is the default setting; it signals a regular contrastive stop segment in PRUPSID. Although the variable was seldom used in UPSID, Maddieson (1984: 170) ascribes the following meanings to the other values:

"1 – Indicates a segment of extremely low frequency (e.g. it only occurs in a handful of words or certain morphological markers, but these are well entrenched parts of the language).

2 – Indicates a segment that occurs only in foreign words or unassimilated loans but these are frequent enough to consider including the segment in the inventory.

3 – Indicates a segment, which is posited in underlying forms to account for some phonological patterning but which is neutralized in surface forms. (Very rarely used).

4 – Indicates a segment which is treated as phonemic in UPSID but which may be regarded as derived from other underlying segments. (Very rarely used).

5 – Indicates a segment which although apparently a genuine member of the inventory, is described in particularly obscure, or contradictory fashion (e.g. a segment in Ashuslay, 814, described as simultaneously a (velar) stop and a lateral)."