Quantitative approaches to problems in linguistics

Studies in honour of Phil Rose

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Phil Rose: A short biography

Ann Kumar, Cathryn Donohue, Shunichi Ishihara

Phil was born in London, though his family later moved to the countryside, which was more congenial than the town for an athletic boy. Phil's father came from a well-to-do country family and was duly sent off to a public school as a boarder – his school days ending prematurely when, a mere 14 years old, he enlisted by falsifying his age. He was a decorated war hero particularly for his work with the French Resistance. Phil's mother was also heroic and actively involved in the war effort, driving ambulances for the Women's Auxiliary Air Force in the war to pick up injured pilots. These ambulances were huge, cumbersome vehicles requiring special training and a special licence to drive, and dealing with the seriously wounded was no picnic either.

Phil's father realized early in the piece that he had an exceptional son, who was precociously gifted both as a cricketer and as a chess player. Besides coaching him in cricket and chess he also provided Phil with a well-rounded education developing all his abilities. Perhaps because of his own country origins, he was an enthusiastic naturalist and took young Phil on field trips identifying the fauna from *The Boys Book of Beasts*. (One of Phil's hobbies is assembling animal skeletons!) In secondary school Phil was an outstanding student and was Head Boy in his final year, but he was also passionate about playing sport – he was Captain of Cricket and Captain of Rugby and was even recruited to play in adult cricket sides from the age of about thirteen or fourteen. Though he was always proud to contribute to his team's success, his mother was far less inclined to discount the cost in injuries, which on one occasion included a bloody broken nose.

Phil attended the University of Manchester for his undergraduate studies. His major specialization was German, in which he had already acquired considerable competence at school, though during the in-country period of his German training he started studying Chinese and Japanese thanks to a scholarship he received to study at Erlangen. He also studied Russian, and graduated with First Class Honours. He subsequently gained the London Dip. IPA (First Class).

Phil continued to study Chinese, which was to be at the centre of his academic career, teaching himself from an old Linguaphone course with 78-rpm records and working at it while commuting between work and his home in East Grinstead. He undertook his postgraduate studies at Cambridge University, focusing on Chinese and solidifying his career path in tone and acoustics. He completed both his M.A. and Ph.D. under the direction of Paul Kratochvil, author of *The Chinese Language Today* and an expert on tones and tone sandhi, who also, Phil says, taught him to write English well.

Phil was recruited to the A.N.U. by Bob Dixon in the year Margaret Thatcher became Prime Minister of the U.K. (1979). He spent ten years as a tutor though he was actually the lecturer in charge of major courses. At the same time he did an enormous amount of reading across the whole discipline of linguistics. Although he always claims to know very little of other branches of the discipline than phonetics, he has in fact been intellectually engaged well beyond his own specialty, and his opinions are always well-considered.

Teaching has always been a vocation and not just a job for Phil. In a review of the Department of Linguistics it was clear that he was a quite exceptional teacher: among many appreciative assessments one student commented "Even in a department of good teachers, Phil Rose stands out". His dedicated and inspiring teaching was nowhere put to better effect than in the first-year class, which was the bedrock of the linguistics program. He taught this over a long period, and in setting the numerous assignments for this course he succeeded in making them not only challenging, but also fun. In his phonetics courses, he would always spend a lot of time with every student setting up and monitoring their course project, ensuring that they produced the best possible work despite the loss of the phonetics lab technician. Compromise was anathema to him and he continued to maintain the high standards he set himself for both his undergraduate and his graduate students, even as the linguistics program was progressively cut down despite glowing external reviews recommending increased staffing.

Despite his very heavy teaching load Phil produced a stream of publications of the highest quality. His publications on tone covered not only Chinese but also Thai, and other languages; he even made a study of Tibetan spelling chant. In contrast to his notable patience with students of all calibres, he had no patience at all with the ever-increasing number of unstructured and rambling meetings on university procedures and 'restructuring' that impinged on time available for activities such as teaching and research that he considered much more important.

The second main focus of Phil's academic career began when his former student Mark Durie recommended him to someone with a forensic problem as far and away the best qualified and most careful and conscientious person. How right this judgment was to prove! After working in this field for some years Phil produced the pioneering book *Forensic Speaker Identification* (Rose 2002) introducing a new, Bayesian, methodology to the field. The book was dedicated to his mum, who died the day before she could see the finished book, and his dad 'who taught him how to observe'. He established this Bayesian approach in the discipline of forensic voice comparison in Australia. His pioneering work led to him being chosen as keynote speaker at Odyssey 2004—The Speaker and Language Recognition Workshop in Toledo, Spain, which was hosted by the Biometric Recognition Group of Universidad Autónoma de Madrid. This in turn led to an ongoing collaboration with Spanish Bayesian speech scientists at the Universidad Autónoma de Madrid. One of the significant outcomes from this collaboration is the publication of Gonzalez-Rodriguez, Rose, Ramos, Toledano & Ortega-Garcia (2007) in which it is demonstrated how traditional and automatic forensic voice comparison methodologies meet the court admissibility requirements. The award of a British Academy Professorship enabled him to further improve his statistical competence in collaboration with colleagues (such as Colin Aitken and David Lucy) of the Joseph Bell Centre for Forensic Statistics and Legal Reasoning at the University of Edinburgh. His research collaborations are not limited to Western countries. In some of Phil's papers on forensic voice comparison (e.g. Rose, Lucy & Osanai 2004; Rose 2011a; 2011b), Japanese is used as the target language, due to the successful collaboration with the National Research Institute of Police Science, Japan.

As his reputation grew, Phil undertook an increasingly heavy load of forensic casework. Among his many cases the Bain case in New Zealand is perhaps the most striking example of his contribution to the dispensation of justice. David Bain had served more than 13 years in prison for the murders of his parents and siblings, before a retrial was ordered in 2009. Phil was the court's expert witness and rather than focusing on what he heard, Phil rightly pointed

out that what anyone hears is irrelevant, what matters is what Bain said, something that can be established with acoustic analysis. Phil's meticulous analysis of the disputed utterance that the police claimed was clearly an admission of guilt by David Bain was the most telling exposure of the danger of this claim by any expert. Bain was subsequently acquitted after his long ordeal and a second trial.

In 2007 Phil was awarded a large ARC grant on a forensic voice comparison project entitled *Catching Criminals by Their Voice – Combining Automatic and Traditional Methods for Optimum Performance in Forensic Speaker Identification*, and appointed Geoffrey Morrison as his research associate. He also brought Cuiling Zhang from the China Criminal Police University to the ANU thanks to a small grant from the International Centre for Excellence in Asian Studies, leading to the introduction of Bayesian forensic voice comparison to China. They produced many important publications advancing the professional standards of forensic voice comparison including Rose and Morrison (2009), Morrison, Zhang and Rose (2011), Morrison, Rose and Zhang (2012).

Phil spent the first semester of 2012 at the Hong Kong University of Science and Technology, teaching an undergraduate course on the Chinese language and a postgraduate course aimed at establishing whether likelihood ratio-based forensic voice comparison was possible for Chinese – and whether it could be taught in one semester to students with no previous training. The outcome of this latter course was no less than six papers by the students, with Phil as co-author, submitted to and accepted for the 14th Australasian International Conference on Speech Science and Technology (where this volume will be presented). Subjects covered include 'Likelihood ratio-based forensic voice comparison with segmental cepstra from Cantonese and Japanese syllabic/mora nasals'; and 'Likelihood ratio-based forensic voice comparison with Cantonese short-term fundamental frequency distribution parameters'. Phil himself had only one single-author paper accepted – he submitted two, but was told one was the conference limit! On returning to Canberra, he immediately collaborated with Hugh Selby, the legal expert on evaluation of evidence, to write a critique of the draft standards proposed for forensic voice comparison in Australia.

Phil's current major project is a book on southern Wu tone sandhi. Within that framework he has already completed a comprehensive study of Wenzhou (溫州), on which he has already published some papers, and is now writing a monograph focused on Wenzhou morphotonemics. The plan of the book is to analyze both right- and left-branching tone sandhi varieties, as well as intermediate varieties, illustrating features of all systems.

Phil always has many irons in the fire and this book, along with other projects, including a textbook, will keep him busy for many years to come in his retirement from the ANU (but thankfully not from the field!).

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Phil Rose: China, 2007

(Courtesy of Zhu Xiaonong)

Ningbo

Westlake, Hangzhou

The shape and spread of tone*

Mark Donohue
Australian National University

It is not news that tone is a property of language that interacts with other parts of the linguistic system (e.g. Plank 1998 and references therein). This paper examines the distribution of tone languages from the perspective of areal typology, comparing the occurrence of different kinds of tone languages to the regions they are in, the families they belong to, and some of the more salient characteristics of the language beyond its tonal system.

1. Introduction

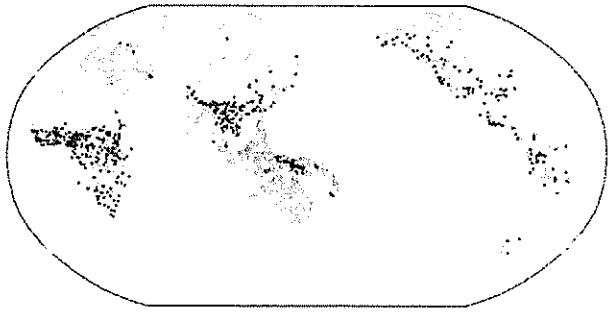
In this chapter we will investigate some of the non-tonal structural elements of language that show correlations with tone. The work is based on a large database, from approximately 1500 languages (database previously reported in Ross & Donohue 2011). The aim is to quantify elements of syllable structure and phonological systems, specifically vowel qualities, onsets and codas, that covary with the presence or absence of tone. This paper will not attempt to examine in great detail the variation possible in a tone language (e.g. Hyman 2006), but will compare the overall shape of contrastive tonal suprasegments and their relationship to the rest of the language in which they occur, following an areal-typological approach (e.g. Nichols 1992). In particular, we find that the presence of tone in a language, and indeed the presence of more elaborated tone (i.e. a tone system with more contrasts) correlates with other kinds of elaboration in the nucleus of the syllable, and less elaboration in the coda.

2. The distribution of tone

Map 1 shows the distribution of tone languages around the world. It is readily apparent that tone languages are not randomly distributed; there are two 'strong' regions where tone languages are nearly universal, in Sub-Saharan Africa and in the Himalayas-Southeast Asia-East Asia spread, an observation that can be found in much earlier writing on tone (e.g. McCawley 1978). In the Americas we find tone languages roughly distributed from a concentration in the north, to an abundance in the centre (e.g. Pike 1948) interspersed with non-tonal languages, to a near absence in the south. All continents except Australia are reported to have tone languages, though there are regions on most continental areas where contrastive tone is absent or nearly absent, such as Western Europe, Remote Oceania, and the southern Andes. While New Guinea appears to be strongly populated with tone languages in

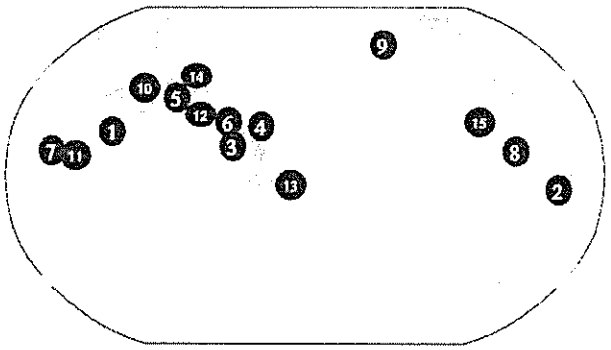
* I would first like to thank Phil Rose for getting me thinking about tone and what it means to be tonal; to Larry Hyman, for suggesting that syllable shape would be relevant to tone; and to my colleagues who have worked on the phonotactics (and phonology) database (available at http://phonotactics.anu.edu.au). The editors and reviewers of this volume have significantly improved the argumentation in this paper.

Map 1, this is in fact an artefact of the large numbers of languages in New Guinea: the actual proportion of tonal language is much lower.[1]



Map 1. The distribution of tonal languages

The goal is to investigate the correlations of tone globally. In order to control for the effects of languages sharing a common ancestor (Galton's problem, which describes the skewing of datasets when they do not fully represent independent data – e.g., Stocking 1968), the behaviour of 15 language families (for which there is variation in the emergence of tone, and reasonable sampling in the database) will also be considered separately from the entire database. These families are shown in map 2. While they are undeniably skewed towards the Old World, this merely reflects the fact that more language families in the Old World are tonal to some extent.



Map 2. Families investigated separately

Key: 1, Afro-Asiatic; 2, Arawak; 3, Austro-Asiatic; 4, Austronesian; 5, Indo-European; 6, Kradai; 7, Mande; 8, Mayan; 9, Na-Dene; 10, Nakh-Daghestanian; 11, Niger-Kongo; 12, Tibeto-Burman; 13, Trans New Guinea; 14, Turkic; 15, Uto-Aztecan.

[1] For the different macro-areas discussed in this paper the proportion of tone languages in this survey is as follows: Africa, 82%; Australia, 0%; Eurasia, 38%; North America, 36%; the Pacific, 20%; South America, 21%.

In the following sections correlations between tone and vowel quality elaboration and syllable shape will be reported.

3. Tone covaries with contrastive vowel qualities

The number of vowel qualities present in a language shows a strong and statistically significant correlation with the presence or absence of tone in a language, and with the number of contrastive tones.[2] While there are no absolute predictions, languages with large numbers of vowels show a higher proportion of tone languages than do languages with low numbers of vowels. Among languages with five contrastive vowels (the modal language type, globally), we find that 34% are tonal; if we examine languages with less than five contrasting vowels we find only 13% of the languages are tonal, while for languages with more than five vowels fully 42% are tonal. The relevant values are shown in table 1, and for a more immediate appreciation of the skewing are displayed in figure 1.

Vowel qualities	Contrastive tones 0	2	3	4	5	6	7	8	9	10	%age tone languages
2–4	214	24	4	3	0	0	0	0	0	0	13%
5	349	115	38	20	4	5	0	0	0	0	34%
6+	436	149	68	55	23	10	3	11	1	1	42%

Table 1. The intersection of tonality and vowel qualities

Key: The numbers indicate how many languages in the sample are found with a combination of certain numbers (2-4; 5; 6 or more) of vowels, and with different numbers of contrastive tones. For instance, the sample contains 349 languages with five vowel systems and no contrastive tone, while 149 languages are found with two contrastive tones and six or more vowels.

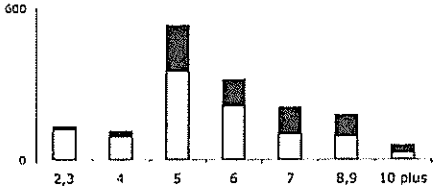


Figure 1. Languages arranged by number of contrastive vowel qualities

Key: Contrastive vowels qualities are shown along the x-axis, and the number of languages in the sample with that number of contrasting vowels are shown along the y-axis. Tone languages are represented by the filled top of the column.

[2] This is not to claim that the number of contrastive tones is the only dimension of complexity involved in the typology of tone languages. Other factors, such as the kinds of tones (level, contour), the domain of tone assignment (mora, syllable, morpheme, word, phrase), the kinds of tone interactions (sandhi, spreading, culminativity) and other factors could all be considered. (Similar comments can be applied to a discussion of vowel variation in phonology, and any other variation in phonology, as discussed in Ross & Donohue (2011).) The number of contrastive tones is, however, easily accessible data.

Clearly the list of languages that contrast a large number of vowel qualities is more heavily populated with tone languages than would be predicted on the basis of an examination of languages with smaller vowel systems. If we take the same three-way division of languages by vowel quality (2-4; 5-6+ vowels) shown in Table 1, and compare the distribution of tone languages and contrastive tones we find significant differences between all three populations ($p < 0.001$, two-tailed t-test).

3.1 The covariance of tone and vowel quality, controlling for family

Although the previous sections revealed a strong and statistically significant correlation between the presence of tone and the number of contrastive vowel qualities, it did so without regard for the source of those languages. In this section we examine fifteen language families, as described in section 2, to determine how robust the correlation between tone and vowel qualities is.

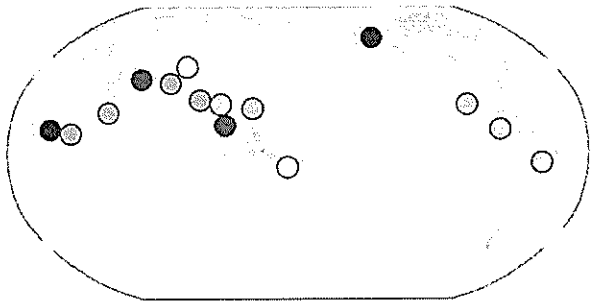
Table 2 shows the degree of correlation (Spearman's ρ/rho) that describes the relation between tone and vowel quality distinctions for the different families investigated. The overwhelming majority of language families in the sample show a positive correlation between tones and vowels, supporting the conclusions from the general global survey.[3] The median correlation is 0.21, and the only families that show negative correlations (that is, families in which languages with more vowels tending to have fewer, or no, tones) are the Turkic and Trans New Guinea families. Turkic is only minimally tonal, as a result of contact, and Trans New Guinea, while robustly tonal, is a heavily contact-affected family. This indicates that the preference for large numbers of vowels in languages with tone is not stable in contact situations.

Family	ρ	Family	ρ	Family	ρ
Trans New Guinea	-0.10	Austronesian	0.07	Niger-Kongo	0.24
Turkic	-0.05	Uto-Aztecan	0.08	Austro-Asiatic	0.35
Kradai	0.00	Afro-Asiatic	0.21	Nakh-Daghestanian	0.41
Mayan	0.00	Tibeto-Burman	0.23	Na-Dene	0.54
Arawakan	0.02	Indo-European	0.24	Mande	0.62

Table 2. The correlation of tonal and vowel qualities by family (rho)

Map 3 shows the distribution of these families, marking high and low correlations between tone and vowel qualities. The overall impression is of a reduction in correlation as one goes east; this is a point, which we shall return to in the next section.

[3] Organising the vowel variation into three bins, as in the previous section, reveals that only the African families Afro-Asiatic and Niger-Kongo is there a statistically significant difference in the tonal populations when the data is split into these smaller samples. Mande, the other African family included, is not represented in the current sample by languages with less than five vowels, but is clearly populated by languages in which the number of contrastive vowel qualities and contrastive tones covary.



Map 3. The covariation of tone and vowel qualities by language family

Key: The darker the shading on the dot representing the language family, the higher the correlation between number of tones and number of vowels.

Although this section has established that the correlation of tone and vowels is independent of genealogical origins, it has not scrutinised these results for the possible effects of geography. We address this question in the following section.

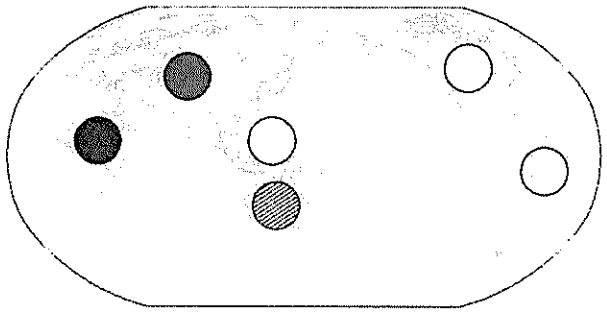
3.2 The covariance of tone and vowel quality, controlling for macro-area

In this section, rather than controlling for the effects of family on tone and vowel, we shall examine the effect of (macro-)area. Although we can (in a principled way) divide the world into six regions, established by reference to sea boundaries (Africa, Australia, Eurasia, North America, the Pacific, and South America) we shall only refer to five of these, since there are no reliable reports of tone languages in Australia.

Table 3 shows the correlation that holds between tone and vowels in the different areas. While there are no areas with negative correlation, the positive correlations are generally trivial, except in the Old World areas of Africa (in which the correlation is significant, $p < 0.01$) and Eurasia (where $p = 0.08$) (two-tailed t-test). The distribution is shown graphically in map 4.

Macro-area	correlation (ρ)
Africa	0.30
Eurasia	0.18
North America	0.01
Pacific	0.03
South America	0.09

Table 3. The covariation of tone and vowel qualities by macro-area



Map 4. The covariation of tone and vowel qualities by macro-area

Key: The darker the shading on the dot representing the macro-area, the higher the correlation between number of tones and number of vowels.

If we examine the simple distribution of contrastive tones against 'eastness' (corresponding to 'rightness' in the maps shown above) we find that tonality drops as languages are located further to the east. Since this is true across multiple contact areas and multiple families, we must conclude that it is more than simply a reflection of shared ancestry or shared (recent) contact.

3.3 The significance of tone for vowel quality

We have seen that there is a global correlation between the presence and number of tones in a language and the number of contrastive vowel qualities. When we examined these traits controlling for language family we found that the correlation was still generally true, but that the degree to which it holds varies widely from family to family. When we examined the correlation controlling for macro-area, we found that the association between tones and vowels hold most strongly in the Old World, and most weakly around the Pacific. Rather than speaking of the vowel quality dimension as showing a universal tendency towards positively correlating with tone, we can better describe the observed facts as showing that Old World tone languages tend to have higher numbers of contrastive vowels, but that this is not true of the languages of the Circum-Pacific region (in the sense used by Bickel & Nichols 2006).

4. Tone covaries with syllable shape

Just as the distribution of vowel quality contrasts is not even across languages with and without tonal properties, so too we find that tone languages have a different distribution across the parameters that determine syllable shapes.

Rather than adopt a unidimensional scale of (for instance) 'simple-medium-complex', we examined separately the following variables: degree of elaboration of the onset (number of consonants, kinds of preferred clusters); degree of elaboration of the coda (number of consonants, preferred consonant types, preferred sequences in clusters). This allowed us to examine the influence of consonant clusters based on their position, not simply their presence. The results of these different comparisons are shown in table 4. Although there is no strong

correlation between tonality and the size of the maximum onset in a syllable, there is a strong and significant *negative* correlation between the presence and amount of tone in a language and the size of the maximum coda: as languages become more tonal, the size of the coda tends to decrease. Nearly half the languages in the sample that do not allow any codas whatsoever are tone languages, despite tone languages accounting for only one third of the sample, and of the 90 languages that allow complex codas with three or more consonants, only 13 are tone languages.

Max.	Contrastive tones										%age tone
Onset	0	2	3	4	5	6	7	8	9	10	languages
1	598	142	71	36	11	4	2	2	1	1	31%
2	282	116	36	34	16	9	1	2	0	0	43%
3+	115	30	3	8	0	2	0	0	0	0	27%

Max.	Contrastive tones										%age tone
Coda	0	2	3	4	5	6	7	8	9	10	languages
0	171	74	33	19	10	3	1	0	0	1	45%
1	529	171	66	55	16	12	2	5	0	0	38%
2	31	10	4	1	0	0	0	0	0	0	33%
3+	77	12	1	0	0	0	0	0	0	0	14%

Table 4. The intersection of tonality and syllable shapes

Key: The numbers indicate how many languages in the sample are found with onsets or codas of certain sizes (0; 1, 2; 3 or more), and with different numbers of contrastive tones. For instance, 598 non-tonal languages in the sample allow only simple (single consonant) onsets, while 16 languages with five contrastive tones allow onsets that can be two consonants long. Of the 158 languages that allow complex onsets three or more consonants long, 43 (27%) have some level of contrastive tone.

Figures 2 and 3 show the data in table 4 in a visual format. In figure 2 we can see that the proportion of tone languages in languages with simple and complex onsets is approximately the same, though the proportion drops off as the size of the onset increases past 2. Figure 3 shows clearly that the proportion of tone languages with complex codas is lower than those with simple or no codas.

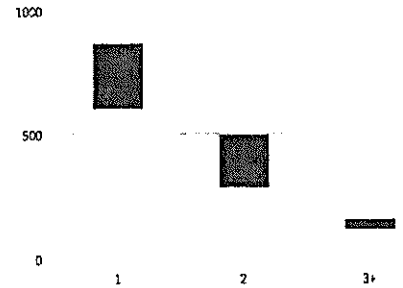


Figure 2. The intersection of tonality and maximal onsets

Key: Maximal onsets are shown along the x-axis, and the languages in the sample with that sized maximal onset are shown along the y-axis. Tone languages are represented by the filled top of the column.

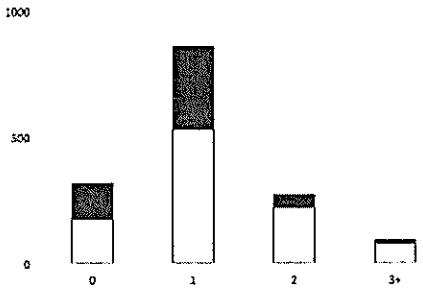


Figure 3. The intersection of tonality and maximal codas

Key: Maximal codas are shown along the x-axis, and the languages in the sample with that sized maximal coda are shown along the y-axis. Tone languages are represented by the filled top of the column.

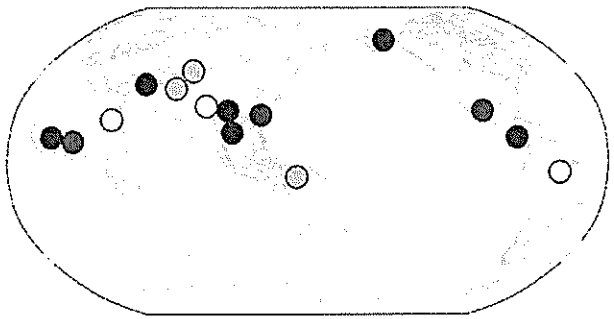
We have established that there is a contrast in syllable structure between tonal and non-tonal languages, in that tone languages show a preference for less complex codas. We now examine these results controlling for family and area.

4.1 The covariance of tone and syllable structure, controlling for family

When we examine our test set of fifteen families for the kinds of covariance reported above we find that there is a wide range of variation, though overall the results do confirm the global results. That said, families such as Tibeto-Burman and Afro-Asiatic show large and significant ($p < 0.05$, two-tailed t-test) negative correlations with onset size: in these families the languages that have one or more tones also show smaller onsets.

Family	ρ	Family	ρ	Family	ρ
Tibeto-Burman	-0.30	Trans New Guinea	0.03	Austro-Asiatic	0.22
Afro-Asiatic	-0.28	Austronesian	0.07	Nakh-Daghestanian	0.24
Arawakan	-0.11	Uto-Aztecan	0.11	Kradai	0.28
Turkic	-0.10	Niger-Kongo	0.12	Na-Dene	0.49
Indo-European	-0.07	Mayan	0.22	Mande	0.55

Table 5. The correlation of tonal and onset size by family (rho)



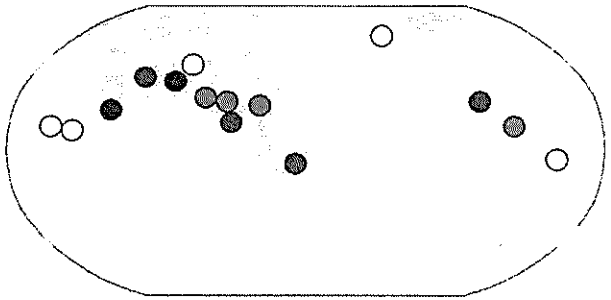
Map 5. The covariation of tone and onset size by language family

Key: The darker the shading on the dot representing the language family, the higher the correlation between number of tones and onset size.

The results obtained when examining codas are dramatically different from the results found for onsets. Here we find that statistically significant ($p < 0.05$, two-tailed t-test) correlations are found for Tibeto-Burman and Niger-Kongo, though in different directions: Tibeto-Burman languages show negative correlations between tonal contrasts and coda size, while Niger-Kongo languages show positive correlations.

Family	ρ	Family	ρ	Family	ρ
Tibeto-Burman	-0.25	Uto-Aztecan	-0.07	Turkic	0.08
Afro-Asiatic	-0.20	Mayan	0.00	Niger-Kongo	0.10
Nakh-Daghestanian	-0.10	Kradai	0.00	Arawakan	0.13
Austro-Asiatic	-0.08	Indo-European	0.03	Na-Dene	0.15
Trans New Guinea	-0.07	Austronesian	0.04	Mande	0.17

Table 6. The correlation of tonal and coda size by family (rho)



Map 6. The covariation of tone and coda size by language family

Key: The darker the shading on the dot representing the language family, the higher the NEGATIVE correlation between number of tones and size of codas.

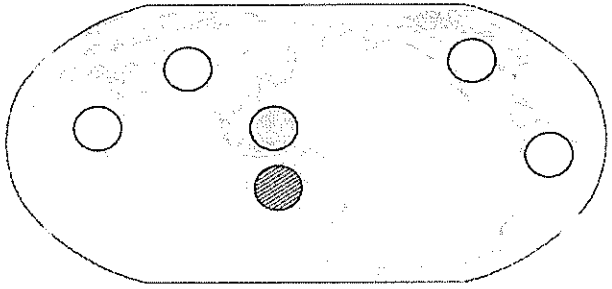
4.2 The covariance of tone and syllable structure, controlling for macro-area

When we examine the distribution of syllable shapes by area, testing for correlations with tone, we find that onsets show very weak correlations with tone, and that correlations with coda size are consistently negative, but not at the same levels. In South America and the Pacific there is no significant correlation, while Africa, the other hotbed of CV languages, shows a much stronger correlation. Africa and Eurasia both show significant, but weak, correlations between tone and onset size ($p < 0.001$), and stronger (and significant) correlations with *complex* codas ($p < 0.001$) (two-tailed t-tests).[4] While there is a globally significant negative correlation between coda size and tonal elaboration, the negative association of tone to coda size is specific to the Old World: Africa and Eurasia.

Tone and Onset size		Tone and coda size	
Macro-area	correlation (ρ)	Macro-area	correlation (ρ)
Africa	-0.10	Eurasia	-0.28
Eurasia	-0.01	North America	-0.16
North America	0.04	Pacific	-0.09
Pacific	0.08	South America	-0.02
South America	-0.03		

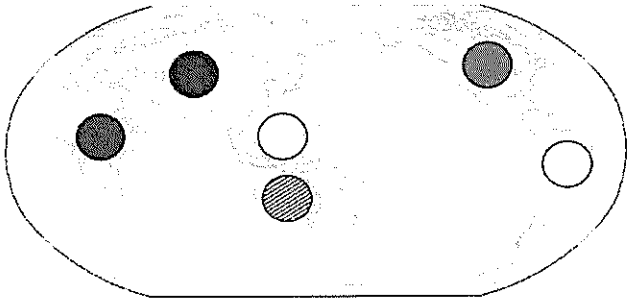
Table 7. The covariation of tone and onset size **(left)** and tone and coda size **(right)** by macro-area

[4] The correlations with codas are significant between languages that allow codas consisting of two or more consonants, and those that allow only one consonant (or none). There are no significant differences between languages that allow *any* codas vs. those that do not, with respect to tone.



Map 7. The covariation of **tone and onset** size by macro-area

Key: The darker the shading on the dot representing the macro-area, the higher the correlation between the size of the maximal onset and number of tones. Darker shading marks LARGER onsets in tone languages.



Map 8. The covariation of **tone and coda** size by macro-area

Key: The darker the shading on the dot representing the macro-area, the higher the *negative* correlation between size of the maximal coda and number of tones. Darker shading marks SMALLER onsets in tone languages.

4.3 The significance of tone for syllable shape

We have seen that there are no overall trends regarding the association of onset sizes with tones present. On the other hand, we found significant overall *negative* correlations between the number of tones in a languages and the size of the coda. This appears to reflect well-known patterns of tonogenesis, whereby various consonants or consonant clusters in the coda of a syllable are lost, but only after affecting the pitch of the syllable.

On the other hand, it is equally clear that these negative correlations are only weakly found in the Pacific and in South America, and that it is in the tone-bearing families of Africa and especially Eurasia that we find a consistently strong negative correlation between tone and coda size; this suggests that processes of tonogenesis were either different in different parts of the world, involving the development of tone without the subsequent loss of final consonants, or else happened so long ago that their effects, in terms of changes to the structure of syllables, can no longer be detected.

5. Conclusions

We have seen that we cannot we identify a 'prototypical tone language', on the basis of its non-tonal features, on a global scale. While certain properties show strong correlations with tone, such as the number of vowel quality contrasts that a language makes, and (inversely) the size of the coda in a language, the distribution and strength of those correlations is not even, and certain families run counter to the modal expectations.

It is perhaps unexpected that some of the most extreme deviations from modality are found in the east of the Tibeto-Burman range, including the languages of Zhejiang province in China (e.g. Rose 1990, 1993, 2000). While we have learned much about the behaviour and possibilities of tone from studies in this region, we still have much to learn about the possibilities offered in the histories of tonal languages from other parts of the world (e.g. Avelino 2004; Donohue 1997).

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Qingtian Wu lexical tone sandhi: Voiceless depressors and allotones*

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Depressor features have been described for many varieties of Wu Chinese, from Shanghai south to the Ou varieties of Wenzhou. Acoustic tone sandhi data from the Chu variety of Qingtian are presented, showing how they refine the particulars of [±depressor]. Acoustic depressor features do not occur through the whole tone pattern, but do occur on syllables with voiceless initials and without initial consonants. No connection is found between depressor syllables and voicing in the data, suggesting that the depressor feature is indeed a feature of morphemes, rather than of segments.

1. Introduction

Qingtian 青田, in the south of Zhejiang province, China, is usually grouped with the Chu (or Lishui) varieties of Wu (Fu et al. 1984). Despite this, the data examined here show features of the Ou varieties it borders – notably the lack of syllables with a glottal stop in the coda (e.g. /sæ/ for 十 'ten' rather than /sæʔ/ or /səʔ/). This paper also demonstrates that it shares with the Ou varieties the presence of depressor morphemes, something not found (so far) in other Chu varieties.

Depressor morphemes are those that cause a lowered tone onset in a given variety. In order to see the surface realisation of depressor features, a comparison must be made between morphemes in different environments. In Wu varieties, the features are visible when comparing word-initial realisations with their word-final equivalents (where "words" are disyllabic nouns read from a list); syllables in isolation, as will be described, have different properties to word-final syllables, in addition to the depressor effects discussed here; word initial tones undergo lexical tone sandhi and are categorically different to both isolation and word-final tone. Thus tone sandhi data is the best way to recognise whether a depressor feature is significant in a variety.

In Qingtian, there are eight isolation (single-syllable) tones (see figure 1 and table 1). Six of these – high falling [41] and convex [341]; short high falling [41] and short convex [341]; and mid [311] and low falling-level [11] – form three pairs with a lowered F0 onset. The falling pairs have a higher form that is a typical falling tone, with a convex tone that forms the other half of the pair; the onset is lowered, while maintaining the contour of the tone from the midpoint onwards (see figure 1 for F0 contours). With the falling-level pair, the basic contour

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