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AT THE INTERSECTION OF SYNCHRONY AND DIACHRONY: A PHONOTACTIC ANALYSIS OF THE LEXICON OF WAN

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Abstract: This study explores the phonotactics of Wan (Mande, Côte d'Ivoire) using an extended version of the lexical statistical method introduced in Pozdniakov & Segerer (2007). A lexical dataset was prepared for analysis based on nouns and verbs extracted from a dictionary. Disyllabic nouns and verbs were analyzed for correlations between the initial and the intervocalic consonant and for correlations between the two vowels. The analysis has confirmed the Similar Place Avoidance generalization proposed as a universal by Pozdniakov & Segerer. It has also revealed significant correlations between the two vowels on two parameters: in height, and in backness. Initial syllables of all nouns and verbs were analyzed for correlations between consonants and vowels and correlations between consonants and tone. The consonant's place of articulation has been revealed to correlate with the vowel's backness, and the consonant's voicing has been revealed to correlate with the vowel's tone. The results suggest that Pozdniakov & Segerer's method can be useful not only when applied to a typological sample but also in the study of phonotatics of individual languages. The specific findings can potentially shed light on the history of Wan and related languages.

Key words: phonotactics, Mande, Wan, Similar Place Avoidance, vowel harmony

1. Introduction

The inspiration for this squib came from a study by Konstantin Pozdniakov and Guillaume Segerer (2007) on the phenomenon of "similar place avoidance", in which they show, in a simple and elegant way, how the same universal tendency of consonant co-occurrence can be detected in lexical data from typologically diverse and genealogically unrelated languages. Their example has led me to explore the phonotactics of one particular language, Wan (Mande, Côte d'Ivoire), by running statistical analyses on its lexicon. Although the scope of this study is limited to a dictionary of one language, I believe that the results might be interesting from a methodological point of view, as they attest to the applicability of Pozdniakov & Segerer's approach to the study of specific languages as well as typological samples.

2. The data

My data comes from an unpublished dictionary comprising, at the time of writing, about 2,500 lexical items. For the purposes of this study the data was extracted into an Excel datasheet. Only nouns and verbs were retained for the analysis, and words from all other classes were removed from the database. This decision was based on the assumption that words from other lexical classes are in general less representative of the phonotactic restrictions of a particular language. Ideophones and onomatopoeias, for example, are well known to have distinctive phonological properties across languages. Words with grammatical function such as particles, auxiliaries and conjunctions commonly result from grammaticalization processes accompanied by phonological weakening; they are restricted to specific syntactic positions, which too may affect their form. Underived adverbs and postpositions are rare in Wan, and they are often difficult to distinguish from nouns.

Nouns and verbs, on the other hand, are both well-defined open classes in Wan, so they were selected as a convenient starting point for the analysis. Wan has little segmental morphology, and the criteria adopted in the dictionary for part of speech classification were syntactic; the definitions relied mostly on the word's distributional properties. Hence, the class of nouns comprised some of the items that fall into other classes in other languages, such as numeral-nouns and property-nouns: rather than constituting separate classes of numerals and adjectives, as in many other languages, they behave syntactically as nouns in Wan.

Wan morphology is tonal; for example, verbs have a mid-tone form in the past tense, and some verbs have a tonally distinct form in the imperative (Nikitina 2008). In the dictionary, such forms were represented by separate entries, but for the purposes of this analysis they were removed from the database (in order to avoid counting each verb multiple times).

Next, excluded from the database were all composite words and words that clearly derive historically from combinations of more than one stem. This was done to avoid having the same word represented multiple times (for example, a noun such as *lē* 'woman' is a common part of kinship terms, terms for professions and other nouns designating humans).

To reduce the number of potential borrowings, I excluded proper nouns (since they are very easily borrowed) and obvious loanwords such as *lī* for 'bed' (from French *lit*) or *dòŋzó* for 'hunter' (from Jula). I also removed words consisting of three or more syllables, since they are extremely unusual for Wan and a large proportion of such words are borrowings.

Finally, I excluded all reduplications, as they often behave in their special ways with respect to phonotactic rules, and I did not want them to introduce "noise" in the very limited data I had at my disposal.

After all these preparatory steps, the database consisted of 1,159 words (943 nouns, 216 verbs). They were annotated for their consonants, vowels, and tone. Statistical analyses were performed using contingency tables and chi-square significance testing. The results are presented in the following sections.

3. Similar Place Avoidance confirmed

Table 1 represents the consonant system of Wan, classified by place and manner of articulation (the elements in brackets represent allophones). The velar nasal *ŋ* is attested (rarely) in intervocalic positions; when occurring on its own or word-finally it shares many properties with vowels and is not treated together with consonants in this study (for example, unlike consonants, it carries tone and undergoes lengthening).

Table 1

Consonants of Wan

	Bilabial	**Labio-dental**	**Alveolar**	**Palatal**	**Velar**	**Labia-lized velar**	**Labio-velar**
Plosive	p b		t d	c ɟ	k g	k^w g^w	kp gb
Fricative		f v	s z				
Implosive / sonorant	ɓ [ɓ, m]		l [ɗ, l, n, ɾ]	j [j, ɲ]	ŋ	w	

Pozdniakov & Segerer (2007) argue that across languages, distributions of consonants within a word are sensitive to the principle of "same place avoidance": word-internal combinations of consonants with the same place of articulation are dispreferred, even when separated by a vowel (see also Mayer et al. 2010). To check whether the same generalization applies to the distribution of consonants in Wan, I grouped the consonants into the four major classes used in Pozdniakov & Segerer's study: labial ("Class P"), dental and alveolar ("Class T"), (alveo-)palatal ("Class C"), and velar ("Class K"). Consonants with mixed articulation (such as labiovelar) are omitted from this comparison (Table 2).

Table 2

Four major consonant types based on place of articulation

	P (labial, labiodental)	**T (dental, alveolar)**	**C (palatal)**	**K (velar)**
Plosive	p b	t d	c ɟ	k g
Fricative	f v	s z		
Implosives/sonorant	ɓ [ɓ, m]	l [ɗ, l, n, r]	j [j, ɲ]	ŋ

For the sake of simplicity, I only consider here disyllabic words with the CVCV(ŋ) structure (word-final *-ŋ* is a tone-bearing unit characterized by a mixture of consonant and vowel properties, cf. its distinct tone in *póŋ̀* 'axe'). Words beginning with a consonant cluster (e.g., *zlò* 'bushbuck') and words with a consonant cluster in the intervocalic position (e.g., *gbótló* 'a kind of mushroom') are not included in the counts. Table 3 presents the resulting distributions of word-initial and intervocalic consonants (the resulting number of 269 tokens is lower than the dataset's total because of the exclusion of monosyllabic words and words with consonant clusters).

Table 3

Distribution of consonant types in the lexical dataset

Consonant 2 **Consonant 1**	**Class "P"**	**Class "T"**	**Class "C"**	**Class "K"**	**Total**
Class "P"	4	49	5	9	67
Class "T"	18	68	3	32	121
Class "C"	7	17	1	6	31
Class "K"	8	34	3	5	50
Total	37	168	12	52	269

It is difficult to interpret that distribution without relying on any statistical tools. Some of the numbers, in particular, are naturally very small (for example, Class C in second position), while others may be enough for drawing conclusions. To start making sense of the distributions, I calculate the expected values for the cells of the table and compare them to the values actually observed in the data. In Table 4, each cell contains three values: the observed value, followed by the expected value (in parentheses) and by a chi-square statistic that measures the observed deviation, or the goodness of fit between the expected and the observed value (in square brackets).

The most significant deviations from the expected value are given in bold (for disproportionately large values) and in grey cells (for disproportionately small values). The most preferred combinations turn out to be T-P (dental/alveolar — velar) and C-P (palatal — bilabial). Using a statistical measure of significance is important because the numbers in the table are relatively small, and sometimes a seemingly striking deviation from the expected value should be ignored when observed with a very small number of examples, and on the contrary, a smaller deviation may prove to be very telling when observed with a large number of examples. For example, nothing can be said about the distribution of the rare Class C, because those numbers that deviate from the expected value are too small to be of significance.

Table 4

Contingency table for the distribution of consonant types: observed value (expected value) [chi-square statistic]

C2 / C1	Class "P"	Class "T"	Class "C"	Class "K"	Total
Class "P"	4 (9.22) [2.95]	49 (41.84) [1.22]	5 (2.99) [1.35]	9 (12.95) [1.21]	67
Class "T"	18 (16.64) [0.11]	68 (75.57) [0.76]	3 (5.40) [1.07]	**32 (23.39) [3.17]**	121
Class "C"	7 (4.26) [1.76]	17 (19.36) [0.29]	1 (1.38) [0.11]	6 (5.99) [0.00]	31
Class "K"	8 (6.88) [0.18]	34 (31.23) [0.25]	3 (2.23) [0.27]	5 (9.67) [2.25]	50
Total	37	168	12	52	269

Chi-square statistic is 16.934; p-value < .049759. The correlation is significant at $p < .05$.

The chi-square test shows, with 95% reliability, that the values of Consonant 1 and Consonant 2 are correlated, i.e. some combinations of consonant types are preferred over others. Crucially, combinations of consonants from the same class (P-P, T-T, C-C, K-K) are systematically underrepresented as compared to the expected value, consistent with Pozdniakov & Segerer's predictions.

The same data confirms Pozdniakov & Segerer's observation that the principle of avoiding the same place of articulation also operates at the more abstract level of the peripheral/medial opposition (known in some traditions as the distinction between coronals and non-coronals). In Table 5, the consonant classes are grouped into two "superclasses" in the way suggested by Pozdniakov & Segerer. We see that the distribution is again asymmetric: initial P+K consonants are significantly more likely to be followed by T+C consonants, as in *kótà* 'back' (78%) than initial T+C consonants, as in *dìsɔ́* 'pants' (59%), and correspondingly, initial T+C consonants are more likely to be followed by P+K consonants, as in *zàkí* 'a kind of drum' (41%) than initial P+K consonants, as in *bɔ̀kà* 'a kind of mushroom' (22%). Taking a different perspective on the same asymmetry, we see that intervocalic T+C are distributed more or less evenly across words starting with P+K and words starting with T+C (91 vs. 89 tokens), even though the latter are overall more frequent in the sample (117 vs. 152); thus, despite the seemingly even distribution, T+C is overrepresented after P+K (78%) as compared to after T+C (only 59%). Overall, as predicted by Pozdniakov & Segerer, the same principle of avoiding same place articulation holds for Table 5, with a much higher level of statistical significance.

Table 5

Distribution of consonant superclasses

C2 **C1**	**Peripheral (P + K)**	**Medial (T + C)**	**Total**
Peripheral (P + K)	26 (22%)	**91 (78%)**	117 (100%)
Medial (T + C)	**63 (41%)**	89 (59%)	152 (100%)
Total	89	180	269

Fisher exact p-value < 0.001 (2-Tailed). The correlation is highly significant.

In short, Pozdniakov & Segerer's generalization is confirmed in Wan: consonants with the same place of articulation are avoided in CVCV(ŋ) structures. It is important to note that the same dataset did not produce a significant result for the distribution of other consonant features. Consider, for example, the distribution of voiceless vs. voiced vs. sonorant consonants in Table 6 (compared to Table 3, this dataset includes labiovelars and labialized velars, hence a higher total number).

Table 6

Distribution of voiceless, voiced, and sonorant consonants in CVCV(V) structures

C1 \ **C2**	**Voiceless**	**Voiced**	**Sonorant**	**Total**
Voiceless	26 (23.82) [0.20]	23 (27.56) [0.75]	107 (104.62) [0.05]	156
Voiced	17 (17.87) [0.04]	24 (20.67) [0.54]	76 (78.47) [0.08]	117
Sonorant	8 (9.31) [0.19]	12 (10.78) [0.14]	41 (40.91) [0.00]	61
Total	51	59	224	334

The chi-square statistic is 1.9886; p-value is .737857. The correlation is **not** significant

The overall distribution of voicing types does not show any significant correlation between the first and the second consonant in CVCV(ŋ) structures. The non-significance of this factor makes the observed correlation in place of articulation even more remarkable.

4. Vowel harmony

Impressed by the evidence for the avoidance of same place articulation in consonants, I used the same dataset to search for other correlations between different phonological features, starting with possible interactions of vowels across the consonant that separates them. For this analysis, I used words of the (C)VC(C)V(ŋ) type, i.e. disyllabic words that do not necessarily start with a consonant but which necessarily feature one or more consonants in the intervocalic position. I was interested to see if the vowels could be shown to interact across the consonants and consonant clusters that separate them.

Tables 7 and 8 classify the vowels of Wan according to their backness and height (/a/ is classified here as central based on preliminary observations, but its actual status is yet to be confirmed). Front vowels turn out to be considerably more frequent than central and back vowels in the second position, while back vowels are more frequent in the first position. Mid vowels are overall more frequent than low and high vowels, independent of position. This is due in part to the decision to group together vowels with two distinct height values (e, o and ɛ, ɔ, which are only distinguished in non-nasal environments). The large number of front and mid vowels makes it easier for the statistical method to detect asymmetries in their distribution, but does not otherwise predict or affect the results.

Table 7

Distribution of vowels according to backness (in disyllabic words with at least one consonant in the intervocalic position)

Vowel 2 Vowel 1	Front (i, e, ɛ)	Central (a)	Back (o, ɔ, u)	Total
Front	104	38	13	155
Central	51	45	32	128
Back	69	33	79	181
Total	224	116	124	464

Table 8

Distribution of vowels according to height (in disyllabic words with at least one consonant in the intervocalic position)

Vowel 2 Vowel 1	Low (a)	Mid (o, ɔ, e, ɛ)	High (i, u)	Total
Low	45	59	24	128
Mid	40	143	74	257
High	31	21	27	79
Total	116	223	125	464

A chi-square test was again performed to measure the goodness of fit between the observed and the expected values. The results in Tables 9 and 10 point to a tendency for vowels to harmonize across the consonant(s) on both of these parameters. As before, the observed value is followed by the expected value (in parentheses) and a measure of the observed deviation (the chi-square statistic in square brackets). Numbers that deviate the most are given in bold (if they exceed the expected value) or in grey cells (if they are lower than expected). Cells that are neither in bold nor shaded contain values that may deviate from the expected value but the difference is not significant, either because the degree of deviation is negligible or because the absolute number is too small to draw any conclusion.

Table 9

Correlations in backness

Vowel 2 **Vowel 1**	**Front (i, e, ɛ)**	**Central (a)**	**Back (o, ɔ, u)**	**Total**
Front	**104 (74.83) [11.37]**	38 (38.75) [0.01]	13 (41.42) [19.50]	155
Central	51 (61.79) [1.89]	**45 (32.00) [5.28]**	32 (34.21) [0.14]	128
Back	69 (87.38) [3.87]	33 (45.25) [3.32]	**79 (48.37) [19.40]**	181
Total	224	116	**124**	464

The chi-square statistic is 64.7762; p-value is < 0.00001. The correlation is highly significant

In sum, the distributions in the tables suggest that the choice of the first and the second vowel is correlated, with a tendency for the vowels to share the features of backness and height. In addition to that, certain vowel combinations tend to be avoided. For example, when a front vowel combines with a back vowel, they show a strong preference for the Back-Front order (as in *bólì* ‘goat’) as opposed to the Front-Back order (as in *pīlɔ̄ŋ* ‘two’). Similarly, when a high vowel combines with a low vowel, there is a strong preference for the High-

Table 10

Correlations in height

Vowel 2 / Vowel 1	Low (a)	Mid (o, ɔ, e, ɛ)	High (i, u)	Total
Low	**45 (32.00) [5.28]**	59 (61.52) [0.10]	24 (34.48) [3.19]	128
Mid	40 (64.25) [9.15]	**143 (123.52) [3.07]**	74 (69.23) [0.33]	257
High	**31 (19.75) [6.41]**	21 (37.97) [7.58]	27 (21.28) [1.54]	79
Total	116	223	125	464

The chi-square statistic is 36.6526; p-value is < 0.00001. The correlation is highly significant

Low order (iCa, uCa, as in *dìnà* 'stand') as opposed to the opposite one (aCi, aCu, as in *gbànì* 'serval'). These ordering preferences might reflect mechanisms of language change that operate or have recently operated in Wan, but the present analysis is not fine-grained enough to account for them.

The analysis ignores potential correlations between the features of backness and height, and more sophisticated statistical tools are needed to disentangle the effects of these features. It is also important, at the next stage of the analysis, to control for the effect of the distinction between spread vs. rounded vowels, which, as a reviewer points out, may contribute to the observed asymmetries. Yet even this simple analysis is sufficient to suggest a direction in which phonotactic effects of different phonological features can be further explored. It suggests that some features show a tendency to harmonize across syllable boundaries (such as backness and height in vowels), while others tend towards dissimilation (such as place of articulation in consonants), and still others show no significant correlation (such as the distinction between voiceless, voiced and sonorant consonants). Narrowing down on the exact determinants of these effects and searching for an explanation is a step that should follow.

5. Consonant-vowel correlations

Space is too limited to give a full description of correlations observed in my dataset. I will therefore restrict the discussion to correlations that I found most interesting as illustration of different ways in which features may or may not depend on each other.

To test for correlations between the value of the consonant and the value of the vowel that follows it, I considered first syllables of all words starting with a single consonant (words starting with CV-). Non-initial syllables were not considered, to reduce possible "noise" from vowel harmony and constraints on consonant combinations. Vowels were classified according to their height and backness, and consonants were classified according to their voicing type (voiceless, voiced, sonorant) and according to their place of articulation as described in previous sections (Classes "P", "T", "C", "K"). I then tested for four types of consonant-vowel correlations: voicing vs. height, voicing vs. backness, place of articulation vs. height, and place of articulation vs. backness.

Three of the four combinations revealed no correlation, suggesting that the relevant features are independent. The consonant's voicing type was not correlated with either the vowel's height or its backness, and the consonant's place of articulation was not correlated with the vowel's height. A strong correlation was observed, however, between the consonant's place of articulation and the vowel's backness, as demonstrated in Table 11 (analyzed in Table 12).

Table 11

Consonant-vowel combinations: place of articulation vs. backness (words starting with a single consonant)

Vowel **Consonant**	**Front** **(i, e, ɛ)**	**Central** **(a)**	**Back** **(o, ɔ, u)**	**Total**
Class "P"	65	49	65	179
Class "T"	123	62	124	309
Class "C"	42	10	24	76
Class "K"	10	29	72	111
Total	240	150	285	675

Table 12

Place of articulation vs. backness: observed vs. expected values

Vowel Consonant	**Front (i, e, ɛ)**	**Central (a)**	**Back (o, ɔ, u)**	**Total**
Class “P”	65 (63.64) [0.03]	49 (39.78) [2.14]	65 (75.58) [1.48]	179
Class “T”	123 (109.87) [1.57]	62 (68.67) [0.65]	124 (130.47) [0.32]	309
Class “C”	**42 (27.02) [8.30]**	10 (16.89) [2.81]	24 (32.09) [2.04]	76
Class “K”	10 (39.47) [22.00]	29 (24.67) [0.76]	**72 (46.87) [13.48]**	111
Total	240	150	285	675

The chi-square statistic is 55.576; p-value is < 0.00001. The correlation is highly significant

Table 12 shows that the choice of a vowel is dependent on the consonant’s place of articulation, at least for some of the place of articulation types. In particular, there is a strong preference for front vowels with palatals, and for back vowels, with velars. Combinations of velars with front vowels tend to be avoided.

Like vowel harmony, the consonant-vowel correlations may reflect regularities of language change characterizing the history of Wan, or perhaps they may be grounded in universal articulatory or acoustic principles (see, for example, Tyler & Langsdale 1996 for discussion of similar associations in developmental data).

6. Correlations with tone

The final set of correlations I checked concerns the interaction of segmental features with tone. For this, I considered again the first syllables of all words (mono- or disyllabic) starting with a single consonant. I annotated them for tone, the vowel’s height and backness, and the consonant’s voicing and place of articulation.

Wan has three underlying tones: /H/, /M/, and /L/, but not all syllables are associated with tone. Toneless syllables can be realized variably as H, M or L, depending on syntactic environment (Nikitina 2019). Words with toneless syllables have been omitted from tone-related counts.

No significant correlation could be identified between tone and the vowel's height or the vowel's backness. Similarly undetected were correlations between tone and the consonant's place of articulation. Consonant voicing, on the other hand, proved to be highly correlated with tone: syllables starting with voiceless consonants were predominantly High, and syllables starting with voiced consonants were predominantly Low (Tables 13 and 14).

Table 13

Distributions of initial consonants and the syllable's tone (words starting with a single consonant; Neutral tone excluded)

Tone **Consonant**	**High**	**Low**	**Mid**	**Total**
Voiceless	160	45	88	293
Voiced	25	215	52	292
Sonorant	21	19	18	58
Total	206	279	158	643

Table 14

Correlations between consonant voicing and tone

Tone **Consonant**	**High**	**Low**	**Mid**	**Total**
Voiceless	**160 (93.87) [46.59]**	45 (127.13) [53.06]	88 (72.00) [3.56]	293
Voiced	25 (93.55) [50.23]	**215 (126.70) [61.54]**	52 (71.75) [5.44]	292
Sonorant	21 (18.58) [0.31]	19 (25.17) [1.51]	18 (14.25) [0.99]	58
Total	206	279	158	643

The chi-square statistic is 223.2245; the p-value is < 0.00001. The result is highly significant

The observed correlation is not very surprising in view of the well-studied tone-depressing properties of voiced consonants (House & Fairbanks 1952; Hombert et al. 1979). It is likely grounded in mechanisms of change driven by such acoustic effects (although see Maddieson 1978 on possible reverse effects, i.e. effects of tone on adjacent consonants), and it would be interesting to explore this change in more detail using traditional comparative methods (including whether it is still ongoing or should be traced to an earlier period in the history of the language).

Symptomatically, the tendency represented in Table 14 is especially pronounced in verbs, where the choice between High and Low tone is virtually predetermined by the initial consonant (at least in the case of voiced and voiceless consonants, i.e. consonants with a voiced or voiceless counterpart). This asymmetry may have to do with the relative diachronic stability of the class of verbs as opposed to nouns: nouns show a greater proportion of borrowings as compared to verbs, and a larger overall number of observed tonal patterns.

7. Conclusion

Due to space limitations, this study is restricted to only partial analysis of a single lexical dataset. Its major goal was to illustrate a direction of research inspired by the study co-authored by Konstantin Pozdniakov. The data presented here raises important questions concerning phonotactic typology, many of which straddle the borderline between synchrony and diachrony that he has been so compellingly exploring in his work.

What are the sources of the observed tendencies? Which of the tendencies can be expected to apply across languages and which are likely to turn out highly language-specific? What diachronic mechanisms are responsible for them, and at what stage in the history of Wan did the correlations emerge? For example, does the prominence of foot as a phonotactic unit with high degree of integration play any role in the development of any of the correlations, see Kuznetsova (2007), Vydrine (2010)? Are speakers sensitive to such correlations and in what ways? Can statistical preferences of the type here explored shed more light, when compared across languages, on genealogical relationships between languages?

The correlations also raise a number of methodological questions, including perhaps the most "modern" one: Can the methodology adopted in Pozdniakov & Segerer (2007) be taken further on a path towards automatic detection of statistical patterns in lexical data, including more subtle, non-trivial correlations that cannot be a priori expected and which escape the naked eye?

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