Studying Tonal Complexity, with a special reference to Mande languages[1]

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Linguists tend to believe that total complexity of human languages is invariable. In order to test this hypothesis empirically, we need to calculate the complexity in different domains of language structure: phonology, morphology, syntax, etc. In this paper I provide some guidelines for documenting tonal systems and evaluating their complexity. I then apply my methodology to the Mande languages of West Africa and test a tonal equi-complexity hypothesis which says that languages with more tonal contrasts tend to have fewer tonal rules and vice versa. The data presented do not support such a concept of tonal equi-complexity in the domain of phonology, but there is a strong positive correlation between the number of tonal contrasts and the number of tonal morphemes. My explanation is that tonal contrasts and tonal morphemes tend to appear as a result of segmental loss, so the two phenomena are likely to co-occur.

0. INTRODUCTION. Linguists working on languages with tone often assert their tonal systems are "complex". However, it is not always clear what is meant by linguistic complexity in general and tonal complexity in particular. In this paper, I provide discussion and some guidelines for distinguishing the different types of tonal complexity so that the researcher can effectively discover not only the tonal contrasts of the language, but also their behavior in context. I attempt to show that rather than being an impressionistic or subjective notion, tonal complexity can be measured in an objective and rigorous manner.

0.1. THE NOTION OF LINGUISTIC COMPLEXITY. As mentioned, the notion of complexity has often been impressionistically invoked in linguistics. Linguists often claimed that human languages should be seen as equally complex, some of them having more complex morphology with simpler syntactic rules and vice versa as claimed, for example, by Hockett (1958: 180). In a detailed account of the history of this idea, Kusters (2003: 1–5) refers to this assumption as the equi-complexity hypothesis. However, until the appearance of McWhorter (2001), very few scholars had tried to test this hypothesis by measuring complexity in an empirical way. McWhorter explicitly criticizes the idea that languages have equal complexity, and claims that creole languages are simpler than "older" languages. The reason why creole languages are simpler is because they are relatively young and

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haven't had enough time to acquire that "ornamental elaboration" of grammar found in older languages. Among the most prominent subsequent publications on linguistic complexity are Kusters (2003), Dahl (2004), Shosted (2006), Miestamo et al. (2008), Sampson et al. (2009) and Trudgill (2011). A comprehensive overview of such complexity studies is presented in Berdichevsky (2012).

A common measure called Kolmogorov complexity (Li & Vitányi 1997) comes from information theory. In this approach complexity is generally equated with the minimal length of the object's description. Since such a measure is problematic for human language (cf. Dahl 2004), linguists prefer the notion of effective complexity which is the minimal length of a description of the object's structure (Gell-Mann 1995). That is, we measure regular linguistic patterns which can be sandhi rules, inflectional classes etc.

The general idea behind modern studies of complexity is that languages do differ in complexity and there are no necessary trade-off relationships between different grammatical domains – for an overview of some possible objections to the idea cf. Kusters (2003: 9–12)[2]. For example, Shosted (2006) was one of the first scholars (probably the first after John McWhorter) who elaborated complexity metrics to test the equi-complexity hypothesis on typological data, and he didn't find any support for a negative correlation between phonological and morphological complexity.

0.2. COMPLEXITY IN TONAL SYSTEMS. There have been quite a few studies focused exclusively on phonological complexity, especially by Maddieson (1984, 2005, 2006, 2007, 2009), the last appearing in a collection (Pellegrino et al. 2009) devoted entirely to phonological complexity. However, most studies discuss segmental phonology paying only rather superficial attention to tone. In his tonal typology Maddieson (2005, 2011), does make a distinction between languages with "simple" vs. "complex" tonal systems.[3] Simple tonal systems have a binary contrast, usually between high and low levels, whereas languages with complex tones have "more complex contrasts". Using this typology, Maddieson tests if there is any correlation between tonal complexity as defined by him and segmental inventories. He shows that tonal complexity correlates positively with segmental complexity, i.e. languages with complex tonal systems tend to have larger segmental inventories. This finding of course contradicts the equi-complexity hypothesis which would predict some kind of phonological compensation. At the same time, there is a negative correlation between tonal complexity and syllable structure complexity. However, this finding should not

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[2] Of course, there are some pitfalls here. One can say that the complexity of a language is something a real user has to struggle with. Thus we should understand it as a relative phenomenon and distinguish between L1 vs. L2 speaker complexity, speaker vs. listener complexity etc. (cf. Kusters 2003). Conversely, we can say that complexity should be defined using independent criteria with no reference to real communication, usually as the minimal length of the description of linguistic structure (cf. Dahl 2004). However, putting aside these details for now, we might conclude that if scientific research is indeed the formalization of common sense, then probably it is not totally incorrect to at least raise the question of relative complexity in human languages.

[3] In Maddieson (2011) refined this typology into a four-way distinction between languages with no tone, with a binary contrast, with three contrasting tones, and with four or more contrasts (Maddieson 2011). However, this does not change the whole picture dramatically.

be interpreted as evidence for equi-complexity, rather it merely proves a well-known fact that tones originate from the loss of consonantal properties, e.g. laryngeal codas (Hombert 1978, among others).

As Maddieson admits himself (Maddieson 2009, also p.c.), simply counting contrasts is not enough to fully measure tonal complexity (and indeed, phonological complexity in general), just as it is not enough to merely establish the number of contrasts when documenting tonal languages. Tonal systems can not only differ in the number of tonal contrasts, but also in the number of rules which affect tones in context.[4] Thus, it seems that for a language to have a binary H/L opposition is simpler than to have five tonal contrasts, but also to have fewer tone rules is simpler than to have more such rules.

Interestingly, tonologists have at times advanced their own equi-complexity hypothesis: at least some believe that the number of contrasts correlates negatively with the number of rules (Larry Hyman, p.c.; Konoshenko 2008). That is, languages with fewer tonal contrasts tend to have more tone rules and vice versa. For example, in Gbali, a northern dialect of Guinean Kpelle, there is only a binary H/L contrast with many tone alternation rules, whereas Liberian Kpelle has a surface H/M/L contrast with fewer tonal alternations (Konoshenko 2008). Does this reveal any general property of tonal systems in human languages, or is this just an accidental combination of tonal features? This is an important consideration, since if there is generality, such a trade-off would be most useful for researchers documenting tonal languages.

In the following discussion I propose a more sophisticated metric for complexity in tonal systems considering not only tonal contrasts, but also the rules of tonal change. I apply this metric to a sample of Mande languages (West Africa), one of which, Guinean Kpelle, I studied myself in the field. I then test the tonal equi-complexity hypothesis on this sample. Mande languages present good data to study tonal complexity as this family comprises languages with various tonal systems distinguishing from 2 to 5 tonal heights. As will be shown, the data provide no support for equi-complexity of tonal systems in general. However, languages with more contrasts tend to have more morphologically conditioned tonal changes. Of course, the results based on just one language family can only be regarded as anecdotal evidence. At the same time, I hope that the complexity metrics discussed in the paper will help other linguists to document tonal languages providing more complete accounts of prosodic systems in these languages as well as to test my findings within other language groups or on broad typological data.

In what follows, I will use the following abbreviations: /eH/ for Extra High, /H/ for High, /M/ for Mid, /L/ for Low, /eL/ for Extra Low, (...) for any floating tone, # for word boundary, ## for pause. The paper is organized as follows. In section 1 I provide a short overview of Mande languages and describe my sampling principles. In section 2 my methodology of evaluating tonal complexity is presented. In section 3 I give a short account of each language in the sample. In section 4 I test the equi-complexity hypothesis and the

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[4] It is quite clear that rules are different, they may be simpler and more complex – cf. Schuh 1978 on the typology of tonal rules and Arends 2001 on evaluating qualitative complexity of rules in general. However, I prefer to stick to the more transparent notion of quantitative complexity as introduced by McWhorter (2001) for want of good criteria of evaluating qualitative complexity so far – cf. also 2.2.1.

correlation between tonal contrasts and tonal morphology. The results are summarized in the conclusion in section 5.

1. DATA AND SAMPLING: MANDE LANGUAGES. The Mande language family of West Africa comprises about 60 languages with vague boundaries between languages and dialects.[5] Mande languages are mainly isolating, have a strict SOVX order, and lack noun classes (Creissels 2005, Nikitina 2009, 2011). There is controversy on whether they should be included into Niger-Congo phylum or not (Williamson & Blench 2000 vs. Dimmendaal 2008). A sketch but a very broad overview based on the available descriptions of Mande tonal systems is given in Vydrin (2002a) though a lot more data have been collected since then.

Tonal systems in Mande are quite typical for Africa as they have mainly level tone oppositions. Phonetic contours also appear, but they are most often analyzed as sequences of discrete level tones. I have been able to obtain information on 43 of the 60 Mande languages, as in Table 1, which I classify by the number of level tone contrasts. However, as I show in section 2, my approach to tonal complexity includes the study of tonal contours and tonal rules in each language as well.

Number of level contrasts[6]	Number of languages	Language groups according to the classification in Vydrin (2009) with examples in parentheses
0	1	Soso-Jalonke (Fuuta Jalon Jalonke[7])
2	22	Manding (Bambara), Mokole (Koranko), Soso-Jalonke (Soso), Vai-Kono (Vai), South-Western (Guinean Kpelle), Soninke-Bozo (Soninke)
3	13	Samogo (Dzuun), Eastern (Bisa), South-Western (Liberian Kpelle), Southern (Beng)
4	6	Samogo (Seenku), Eastern (Boko), Southern (Kla-Dan)
5	1	Southern (Eastern Dan)
Total	43	

TABLE 1. Tonal contrasts in Mande languages

[5] There are 73 entries in the latest version of Ethnologue, but those are rather dialects than languages.

[6] In some languages phonemic contours are also postulated. They are not considered in this table though I include them into my calculation below.

[7] A complete loss of tones in Jalonke can be explained by its large contacts with toneless Fula language (< North Atlantic) (Vydrin 2002). However, anonymous reviewer pointed out that not all Fuuta Jalon Jalonke varieties have lost tone. I used the paper by Lüpke (2005) as a source for this language, and unfortunately, the author does not write explicitly in what villages she did her fieldwork.

As the descriptions of Mande languages vary in completeness and reliability, I have had to narrow my scope and investigate only languages whose tone system has been relatively well described. Thus the smaller sample became biased towards better studied language groups, specifically, Manding, South-Western and Southern Mande. Since I wanted my sample to reflect the proportions of level contrast types in Mande, I considered eight languages with binary contrast, six languages with three levels, four languages with four levels, and the only Mande language with 5 levels (Eastern Dan). In this way I came up with a sample of the 19 languages presented in Table 2.

Number of level contrasts	Number of languages	Languages	Source
2	8	Standard Bamana (< Manding) Koro (< Manding) Niokolo Maninka (<Manding) Kakabe (<Mokole) Vai (< Vai-Kono) Mende (< South-Western) Guinean Looma (< South-Western) Guinean Kpelle (< South-Western)	Dumestre 2003; Vydrin 2008 Creissels 1987 Creissels 2013 Vydrina 2008 Welmers 1976 Dwyer 1973; Innes 1971 Dwyer 1973; Mischenko 2009 Konoshenko 2008, 2009
3	6	Liberian Kpelle (< South-Western) Dzuun (< Samogo) Mwan (< Southern) Mano (< Southern) Beng (< Southern) Guro (< Southern)	Welmers 1962; Leidenfrost, McKay 2005 Solomiac 2007 Perekhvalskaya 2006, ms. Khachaturyan 2010, ms. Paperno 2011 Vydrin 2002b; O.Kuznetsova 2007, ms.; N.Kuznetsova 2007; Kuznetsova et al. 2009
4	4	Yaure (< Southern) Toura (< Southern) Gban (< Southern) Kla-Dan (< Southern)	Hopkins 1982; Kushnir pc. Bearth 1971 Le Saout 1976; Fedotov 2012 Makeeva 2012
5	1	Eastern Dan (< Southern)	Vydrin, Kességbeu 2008, ms.

TABLE 2. Sample of Mande languages

Despite some genetic and bibliographic biases mentioned above, I believe this sample will be instructive anyway because it still covers all types of tonal contrasts found in Mande languages.

2. METHODOLOGY: MEASURING TONAL COMPLEXITY IN MANDE. Describing a tonal language, a researcher should study two separate phenomena which make up a tonal system: paradigmatic contrasts in the tonal inventory and any tonal rules which change underlying tones in context. These two aspects can be viewed as two different types of tonal complexity. I propose to call the first one *paradigmatic complexity*, and the second one *syntagmatic complexity*. Testing the tonal equi-complexity hypothesis means that we should determine if there is any correlation between paradigmatic and syntagmatic complexity in a given sample of languages. In the rest of this section I describe my principles of evaluating paradigmatic and syntagmatic complexity of a tonal system. As the volume has a strong methodological orientation it is particularly appropriate to pay special attention to the methodology of gauging tonal complexity in this study.

2.1. EVALUATING PARADIGMATIC COMPLEXITY. As stated above, I use the term "paradigmatic complexity" for the number of phonemic contrasts in a language. Finding contrasts, i.e. minimal pairs, is a very basic phonological procedure. Tonal languages are quite similar in this respect. However, when establishing the number of tonal contrasts, a researcher is likely to face the problem of contour tones. In most languages I looked at contour tones are described as sequences of phonemic level tones. However, in Gban (Le Saout 1976; Fedotov 2012), in Guro (Kuznetsova 2007), in Eastern Dan (Vydrin & Kessegbeu 2008), phonemic contours are postulated as well. It remains unclear to me—and in some cases also to the linguists working with such languages (Maxim Fedotov p.c.)—whether this is an appropriate interpretation for these languages. However, I included contour tones in the number of contrasts in these languages[8].

Another way of measuring paradigmatic complexity is to count tonal patterns (melodies) associated with morphemes. This approach seems more problematic to me, at least for Mande. First of all, most Mande languages have little or no tonal restrictions on the distribution of tones in trisyllabic morphemes. Second, even if we only look at bisyllabic and monosyllabic morphemes, a problem of peripheral patterns appears. It can be solved quite straightforwardly for Bambara whose two basic melodies H and LH cover about 90% of the lexicon as Dumestre (2003:22) and Vydrin (2008: 8) explicitly claim. However, it is not that clear in other cases. For example, in Dzuun the difference between common and rare patterns is rather gradual (Solomiac 2007: 167-177). In some descriptions where the authors note that all or most combinations of tones are possible, but that some of them are peripheral, no statistics are provided. In such cases I have thus had to make (possibly arbitrary) decisions about the basic melodies myself and include them in my evaluation. Finally, I tested the correlations, but the results of tonal melodies were not substantially different from those with single tones. Since the very procedure of choosing basic melodies is rather vague, I ultimately decided to exclude tonal melodies from my evaluation even if

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[8] In fact, I calculated complexity correlations with contour tones and without them, but this did not change my results significantly.

they may provide insight in a descriptive sense.

2.2. EVALUATING SYNTAGMATIC COMPLEXITY. Establishing the number of basic tonal contrasts can be problematic for some languages, but discovering and evaluating phonological rules is a big challenge whatever language one investigates. Concerning tone, researchers sometimes note the descriptive difficulty that may be faced when the lexical tones identified in one context alternate in another. In such cases one should check whether underlying tones have been identified correctly and if yes, provide a list of rules accounting for all surface changes. The rules should be maximally general and, if possible, should not violate one's typological expectations—see Hyman and Schuh (1974) and Hyman (2007a) for generalizations concerning "natural" vs. "unnatural" tone rules. For our purposes, it is only when a complete account of surface alternations is provided that one is in a position to evaluate the syntagmatic complexity of a language. Quite a few problems arise here so I'll try to be as explicit and as consistent as possible.

2.2.1. The most general and the most difficult problem to tackle arises from the varying descriptions. Accounting for tonal changes is, to a large extent, a matter of interpretation which strongly depends on the author's assumptions about underlying tones. As the anonymous reviewer notes, in many Manding varieties, the hypothesis of an underlying L vs. zero contrast (instead of a L vs. H contrast) simplifies the description of tonal alternations to a considerable extent. Also, the descriptions vary in the degree of their formalization, and a more formal account usually gives more rules than a less formal one. I did my best to keep that in mind doing my calculation but it is close to impossible to make a balanced evaluation based on unbalanced descriptions. This only means that the results of any (micro)typological calculation such as the one presented in this paper should be taken cautiously because the difference in the final scores may be to some extent a result of the difference in the descriptions.

2.2.2. Should we approach rules quantitatively, qualitatively, or both? When McWhorter (2001) suggested quantitative complexity metrics, he was criticized by Arends (2001) who emphasized that complexity should be measured qualitatively as well. In other words, our metrics should capture the fact that individual rules differ in their complexity. The following question thus arises: "[w]hich grammar is more complex, the one with *n* rules, each of complexity *C*, or the one with 2*n* rules, each of complexity C/2?" (Arends 2001: 181). I would ask another question: how in fact should one measure internal rule complexity? Frankly, I don't see any good answer at the moment. So in the current study I measured syntagmatic complexity quantitatively, i.e. by counting rules. However, if my definition of rule (cf. 2.2.3) is applied rigorously, then it often turns out that presumably more complex rules should in fact be analyzed as two or more rules. Thus qualitative complexity can be somehow captured by quantitative metrics.

I should note that I deliberately give equal points to all rules, because I don't see any good procedure of relative rule complexity measurement. So for now one rule gives a language one point. For example, in Guinean Kpelle downdrift affects the whole utterance (Konoshenko 2009: 23). In Liberian Kpelle downdrift only works in utterance-final

position (Welmers 1962: 87-88). However, both languages get one point according to my metrics.

2.2.3. What kind of rules should we look at? I considered all kinds of possible rules as discussed in Hyman & Schuh (1974), Hyman (1975), Schuh (1978), and Hyman (2007a). Although the typology of rules is presented quite extensively in this literature, I'll just identify the basic distinctions important for my study.

The first important distinction is between strictly phonologically conditioned tone rules vs. those whose conditions may also be grammatical (morphological, syntactic). While the former depend strictly on the phonetic or phonological context, e.g. "Underlying /H/ changes to /L/ after /L/", the latter may have grammatical restrictions, e.g. "verbs change lexical /H/ to /L/ in the Past tense". While grammatical tonal changes of this sort are not strictly phonological (vs. morphological in this case), I think that considering the functional use of tone can be useful and parallel to the evaluation of tonal complexity of a language. If a lexeme changes its lexical tone in some grammatical construction, this makes the whole tonality less transparent, exactly as in phonologically induced changes. However, I did not include grammatical tonal changes within the set of syntagmatic phonological rules and did not count them in the overall score for phonological tonal complexity. They were counted separately.[9]

The next distinction, within the group of non-grammatical tone changes, is between automatic and non-automatic tonal changes which together contribute to the syntagmatic complexity of a tonal system. The former take place whenever there is a special phonological context, and the latter are morphosyntactically conditioned. For example, in Guinean Kpelle there is an automatic rule L(H) → LH / __L(H). This rule does not depend on syntax so it applies whenever a sequence of L(H) L(H) occurs. There is also a non-automatic rule L(H) → H/ H__ which only applies within VPs (i.e. verb changes its /L(H)/ melody to /H/ after a direct object with /H/). The distinction between automatic and non-automatic rules is not always clear and it depends on the completeness of the description. So I put allegedly different rules into different boxes, but finally counted them together in the total score for syntagmatic complexity.

There is also a problem of distinguishing between phonetic and phonological rules. In this study I only considered allegedly phonological, i.e. categorical changes, though some of them can still be accounted for phonetically. Thus I admit that some interpretations remain debatable.

Floating tones also complicate the evaluation to some extent. They may have different nature: they may be lexical (as in Koro, Niokolo Maninka, Guinean and Liberian Kpelle, Dzuun), they may be contextual, i.e. appear after the application of some phonological

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[9] I counted the grammatical effect of tones quite superficially just noting whether a concrete tone can appear as a tonal morpheme for some kinds of NPs vs. VPs. So if a tone is used to mark NP heads and some verbal constructions I counted that separately. If a tone marks verbs in different TAM constructions (e.g. /L/ in Positive Past and Negative Imperative in Guinean Kpelle), I didn't count that separately because such details depend on the completeness of the description and so they are not always comparable.

rules (in Koro, Guinean Kpelle), or they may be morphological markers (in Bambara,[10] Koro, Tura, Gban). Thus in the three cases just mentioned floating tones are instances of different components of complexity: lexical floating tones contribute to paradigmatic complexity, contextual ones increase syntagmatic complexity, and when used as morphological markers they should be seen as instances of grammar. I therefore counted all the three types separately including them into the corresponding complexity domains.

2.2.4. When formulating and counting rules, one faces another major question. What constitutes a single rule vs. two rules? In linear generative phonology (Chomsky and Halle 1968), phonological rules are formalized as follows: $A \rightarrow B \ / \ X\_\_Y$, which reads "An element A changes to an element B when preceded by X and followed by Y." Thus a rule consists of three variables: input (A), output (B) and context (X and/or Y). In this study I established that there are two rules whenever any two variables are not identical. Thus if we read something like "/H/ and /M/ change to /L/ after /L/" in a grammar, I consider this to be one rule. If we come across a statement similar to "/H/ changes to /M/, and /M/ changes to /L/ after /L/", I prefer to see it as two rules. Such a boundary may seem arbitrary because many such pairs of rules may be generalized ("Lower each tone to one level after /L/" for the example above).

Let us consider some tonal changes in Yaure as examples of the challenges one faces when counting rules. According to Hopkins (1982), in Yaure, a language with 4 tonal contrasts, the following automatic tonal changes occur among others (they are probably better perceived if tones are given in numbers, so here I will follow the author's representation: 1 = extra-high, 2 = high, 3 = low, 4 = extra-low; cf. section 3.3.1):

(a) $3 \rightarrow 13 \ / \ 1\_\_ \ 1, \ 1\_\_2$
(b) $3 \rightarrow 1 \ / \ 1\_\_3, \ 1\_\_4, \ 1\_\_\#\#$
(c) $4 \rightarrow 14 \ / \ 1\_\_1, \ 1\_\_2, \ 1\_\_3$
(d) $4 \rightarrow 1 \ / \ 1\_\_4, \ 1\_\_\#\#$

The question is: Are these four rules, or two, or just one? We can postulate 4 rules (a), (b), (c), and (d) straightforwardly. Alternatively, we can say there are two rules: Rule 1 comprising (a) and (b): *When preceded by extra-high (1), low (3) changes to 13 when followed by extra-high (1) and high (2), and changes to 1 when followed by low (3), extra-low (4), or a pause.* Rule 2 comprising (c) and (d): *When preceded by extra-high (1), extra-low (4) changes to 14 when followed by extra-high (1), high (2), and low (3), and changes to 1 when followed by extra-low (4), or a pause.*

But Rules 1 and 2 are very similar. We can try to formulate the following general "Big" rule—almost unreadable but nonetheless impressive—which describes all four cases: *When preceded by extra-high (1) tone, low (3) and extra-low (4) become contours starting from the level of the preceding tone (13 or 14) when followed by tones higher than the tones modified (1, 2 against 3, and 1, 2, 3 against 4), but they change to extra-high (1) level when*

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[10] Floating tone can be also lexical in Bambara for a limited number of lexemes (Valentin Vydrin, p.c.).

followed by equal, or lower tones, or a pause (3, 4 or ## for 3; 4, ## for 4).

We could even say something very neat like "Non-extra-high tones change after extra-high…" if the rule worked for high (2) tone as well which seems to be logically possible. But it doesn't (if I have interpreted everything correctly). So our generalization will be either very lengthy and not very general as the "Big" rule, or it will be false as it will predict those changes that don't occur as the last interpretation I suggested. The problem is that, on the one hand, something similar happens to different tones, on the other hand, it's not absolute (tones 3 and 4 change, but not 2). Thus, if a good generalization is not possible, I prefer the atomistic approach and postulate 4 rules, all the while admitting that this is questionable.[11]

Importantly, my atomistic approach often helps to capture quantitatively an otherwise hard-to-pin-down difference in qualitative complexity of the rules. It is clear that the "Big" Rule is very complex, and so I split it into 4 rules giving the language 4 points instead of one.

Finally, I should note that not all rules can be formalized as $A \rightarrow B / X\_\_Y$. For example, downdrift affects sequences of tones, but I counted such rules as well.

2.2.5. Quite often non-automatic and grammatical rules require that lexemes be divided into several classes. There may be only two groups. For example, in Liberian Kpelle there is a non-automatic rule for verbs: $M(H) \rightarrow H / M(H)\_\_, H\_\_$. However, as noted in Leidenfrost & McKay (2005: 64), some verbs follow this rule while others do not, so the rule divides the verbs into two groups. For some languages up to 14 classes are postulated, e.g. tonal marking of verbs in conjoint construction for Eastern Dan (Vydrin ms.). See also Appendix 2 for patterns of non-automatic changes in Mwan, and Appendix 3 for tonal paradigms in Perfective and Imperfective in Yaure.

We could just count the tonal classes in each language, but there are several problems here. First of all, it seems that there appear to be more tonal classes in better described languages, e.g. Eastern Dan, or Guro, especially for more peripheral groups of lexemes, such as adjectives and postpositions. Second, tonal classes often depend on the segmental structure of the words which makes them more predictable, but complicates the calculation. Finally, tonal classes are often unequal in their size: some comprise hundreds of words, and others may only include about ten words.

I suggest the following metric to cope with such problems. If a rule is regular, we just count the rule; it gives a language one point. If a rule divides a group of lexemes into two groups, the language gets 2 points for this rule, so a sign "×2" is added. If a rule makes 3 or more tonal classes, the language gets 3 points with "×3" sign. Also, I only consider nouns and verbs in my evaluation.

2.2.6. Finally, I need to mention the phenomena that were excluded from my scope. I did not count those hypothetical rules which depend on one's analysis. For example, in his description of Koro tonology, Creissels (1987: 87) introduces a rule according to which floating (H) tones are deleted before a non-floating H or a pause. However, in this case we

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[11] Frankly, I think any decision may work provided that we are consistent in our measurement.

may state that (H) is simply not realized on any TBU. I couldn't find any counter-evidence against such an analysis.

I also didn't count optional rules, e.g. downstep in Niokolo Maninka (Creissels 2013) or optional /eL/ marking of nouns in some possessive constructions in Kla-Dan (Makeeva 2012: 5253). Descriptions often state that a rule is optional with no further comments. But non-obligatoriness is gradual. Some rules may be seldomly used (e.g. only by older generation) and are almost non-existent, some are almost obligatory, but not absolutely. It is difficult to evaluate this, so I decided not to count optional rules.

I mostly looked at tonal changes occurring between words and not between roots and affixes (except for some affixes as in Kla-Dan, Eastern Dan and Wobe that are merely tonal). First, there seem to be more idiosyncrasies inside the word, as different word forms have their own formation rules. Second, the amount of information concerning concrete suffixes and word forms strongly depends on the completeness of a language description. Thus I only looked at general patterns of changes between the words as formulated phonologically or morphophonologically. The only exception is Guinean Looma (Mishchenko 2009) where tones on suffixes are often the only indication of the root's lexical tone, so when describing tonal system we cannot neglect tones on suffixes in this language (cf. Appendix 1).

Most Mande languages have very regular and very general tonal rules of compounding. The only exception I came across in my sample is Dzuun. The rules of correspondence between the lexical tones of the nouns and their tones in the compounds are rather probabilistic, and the distribution is more random than regular (Solomiac 2007: 368). This raises the question of how we should understand complexity. If we follow the notion of Kolmogorov complexity as it is done in information theory (cf. Li & Vitányi 1997), then under this approach we'll say that an object consisting of random sequence of elements is more complex than any sequence having regular patterns. Thus Dzuun will get a more complex system of compounding as opposed to languages with regular compounding. Or we can follow the notion of "effective complexity" as introduced by Gell-Mann (1994), where complexity is a measure of regularities (rules), and not of the object itself. Under this approach random systems such as the one in Dzuun will have lower complexity as they don't seem to have rules. As I said at the beginning of this section, I follow Gell-Mann's notion of complexity, as most linguists do (cf. Dahl 2009: 51). In the way I count rules in this study, when counting rules for Dzuun, I excluded compounding which apparently lacks any rules.

Finally, it is possible that I have simply missed some important details concerning tone in Mande, especially grammatical changes. The information on these is usually scattered among different sections of the descriptions, so I may have overlooked something.

3. TONAL SYSTEMS IN MANDE LANGUAGES. In this section I give a brief account of tonal systems in Mande languages from my sample. Some examples of the data I analyzed are given in the Appendices 1, 2, 3.

3.1. LANGUAGES WITH 2 LEVELS CONTRASTED

3.1.1. BAMBARA (< MANDING)
Tonal contrasts: /H/ vs. /L/, also lexical floating (L) (3 pts.)
Paradigmatic complexity score: 3 pts.
Automatic rules: 1) downdrift; 2) downstep (2 pts.)
Non-automatic rules: 1) tonal neutralization in compounds; 2) partial tonal neutralization for Noun + Adjective; 3) partial tonal neutralization for Noun + Numeral; 4) H → L / L__##, L__H for functional words and non-monosyllabic content words (4 pts.);
Syntagmatic complexity score: 2+4=6 pts.
Grammatical rules: no; morphological floating (L) marking referential NPs (1 pt.)

3.1.2. KORO (< MANDING)
Tonal contrasts: /H/ vs. /L/, also lexical floating (H) (3 pts.)
Paradigmatic complexity score: 3 pts.
Automatic rules: 1) L → eL / L__ ##; 2) H → eH / H__##; 3) L…L → H…H(L) / H__H, H__##, (H)__H, (H)__##; 4) L…L → H…HL / H__(H), (H)__(H); 5) H → L(H) / L__, (L)__; 6) (H)L → H(L); 7) downstep; 8) H(L) → HL __##; 9) downdrift; (9 pts.)
Non-automatic rules: 1) tonal neutralization in compounds; 2) LHH → LLH for Noun + Numeral (2 pts.);
Contextual floating tones: (L), (H) (2 pts.)
Syntagmatic complexity score: 9+2+2=13 pts.
Grammatical rules: no; morphological (LH) marking definite NPs (1 pt.)

3.1.3. NIOKOLO MANINKA (< MANDING)
Tonal contrasts: /H/ vs. /Ø/, also lexical floating (H) (3 pts.)
Paradigmatic complexity score: 3 pts.
Automatic rules: 1) Ø → H / __#Ø (for ultimate Ø on light syllables); 2) downdrift (2 pts.)
Non-automatic rules: 1) tonal neutralization in compounds; 2) partial tonal neutralization for Noun + Adjective; 3) partial tonal neutralization for Noun + Numeral (3 pts.)
Syntagmatic complexity score: 2+3=5 pts.
Grammatical rules: no (0 pts.)

3.1.4. KAKABE (< MOKOLE)
Tonal contrasts: /H/ vs. /L/ (2 pts.)
Paradigmatic complexity score: 2 pts.
Automatic rules: 1) H → L / L__##, L__H; 2) downdrift (2 pts.)
Non-automatic rules: 1) tonal neutralization in compounds (1 point)
Syntagmatic complexity score: 2+1=3 pts.
Grammatical rules: no (0 pts.)

3.1.5. VAI (< VAI-KONO)
Tonal contrasts: /H/ vs. /L/ (2 pts.)
Paradigmatic complexity score: 2 pts.
Automatic rules: LH → M / H__H, H__L (for LH on a short vowel) (1 pt.)

Non-automatic rules: 1) tonal neutralization in compounds; 2) LH → LL / __H for nouns before modifiers in NP, verbs in VP (2 pts.)

Syntagmatic complexity score: 1+2=3 pts.

Grammatical rules: 1) /L/ marking the second component of a compound; 2) /H/ marking the second component of a compound; 3) /L/ marking verbs in different TAM constructions (3 pts.)

3.1.6. MENDE (< SOUTH-WESTERN)

Tonal contrasts: /H/ vs. /L/ (2 pts.)

Paradigmatic complexity score: 2 pts.

Automatic rules: 1) H → L / L__H; 2) HL → HH not before pause; 3) downdrift (3 pts.)

Non-automatic rules: 1) LH + L → L + HL in compounds and alienable possessives (1 pt.)

Syntagmatic complexity score: 3+1=4 pts.

Grammatical rules: 1) /L/ marking the second component of a compound and alienable possessor; 2) /L/ marking verbs in different TAM constructions (2 pts.)

3.1.7. LOOMA (< SOUTH-WESTERN)

Tonal contrasts: /H/ vs. /L/ (2 pts.)

Paradigmatic complexity score: 2 pts.

Automatic rules: 1) downdrift (1 point)

Non-automatic rules: 11 rules including irregularities – cf. Appendix 1 (11 pts.);

Syntagmatic complexity score: 1+11=12 pts.

Grammatical rules: 1) /L/ marking attributive modifiers; 2) /H/ marking possessed NPs (2 pts.)

3.1.8. GUINEAN KPELLE (< SOUTH-WESTERN)

Tonal contrasts: /H/ vs. /L/, also lexical floating (H) (3 pts.)

Paradigmatic complexity score: 3 pts.

Automatic rules: 1) HL → H(L) for ultimate syllable not before pause; 2) L(H) → LH / __L(H), __L3SG (L3SG stands for grammatical L marking 3SG); 3) downdrift; 4) downstep (4 pts.)

Non-automatic rules: 1) L → HL / H__, (H)__ for noun and verb phrases; 2) L(H) → H / H__, (H)__ for VPs (2 pts.)

Contextual floating tones: (L) (1 pt.)

Syntagmatic complexity score: 4+2+1=7 pts.

Grammatical rules: 1) /L/ marking the second component of a compound; 2) /L/ marking verbs in different TAM constructions (2 pts.)

3.2. LANGUAGES WITH 3 LEVELS CONTRASTED

3.2.1. LIBERIAN KPELLE (< SOUTH-WESTERN)

Tonal contrasts: /H/ vs. /M/ vs. /L/[12], also lexical floating (H) (4 pts.)

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[12] This tripartite contrast can be analyzed as underlyingly binary in Liberian Kpelle, but here I follow Welmers's analysis with three contrastive levels.

Paradigmatic complexity score: 4 pts.
Automatic rules: 1) M(H) → MH / __L3SG (L3SG stands for grammatical L marking 3SG); 2) downdrift on final /H/ and /M/ (2 pts.)
Non-automatic rules: 1) L → HL / M(H)__ for noun and verb phrases; 2) M(H) → H/ H__, (H)__ for verbs, but not all of them => ×2; 3) M(H) → MH / __M(H) for NPs (4 pts.)
Syntagmatic complexity score: 2+4=6 pts.
Grammatical rules: 1) /L/ marking the second component of a compound; 2) /L/ marking verbs in different TAM constructions (2 pts.)

3.2.2. DZUUN (< SAMOGO)
Tonal contrasts: /H/ vs. /M/ vs. /L/, also lexical (H) (4 pts.)
Paradigmatic complexity score: 4 pts.
Automatic rules: 1) downdrift (1 pt.)
Non-automatic rules: 1) L, M → H / (H)__ (1 pt.)
Syntagmatic complexity score: 1+1=2 pts.
Grammatical rules: no? (0 pts.)

3.2.3. MANO (< SOUTHERN)
Tonal contrasts: /H/ vs. /M/ vs. /L/ (3 pts.)
Paradigmatic complexity score: 3 pts.
Automatic rules: 1) downdrift (1 pt.)
Non-automatic rules: no
Syntagmatic complexity score: 1 pt.
Grammatical rules: 1) /L/ marking the second component of a compound when preceded by a nominalized verb, otherwise optional; 2) /L/ marking verb in conjoint construction; 3) /L/ marking nominalizations with postverbal arguments; 4) probably 6 patterns of tone change on verbs in Imperfective => ×3 (6 pts.)

3.2.4. MWAN (< SOUTHERN)
Tonal contrasts: /H/ vs. /M/ vs. /L/ (3 pts.)
Paradigmatic complexity score: 3 pts.
Automatic rules: no
Non-automatic rules: 1) lexemes differ in their tonal behavior after /L/, /M/, /H/; there seem to be eight patterns – cf. Appendix 2 => ×3 (3 pts.)
Syntagmatic complexity score: 0+3=3 pts.
Grammatical rules: 1) /M/ marking verb in Habitual; 2) verbs with CVV and CVLV structure get /L/ on the second mora in Imperative (2 pts.)

3.2.5. BENG (< SOUTHERN)
Tonal contrasts: /H/ vs. /M/ vs. /L/ (3 pts.)
Paradigmatic complexity score: 3 pts.
Automatic rules: 1) LH → L / non-L; 2) HL → H / __L; 3) ML → M / __L; 4) L → H / H__L; 5) downstep (5 pts.)
Non-automatic rules: 1) L → HL / H__ for verbs after subject pronouns (1 pt.)
Contextual floating tones: (L) (1 pt.)

Syntagmatic complexity score: 5+1+1=7 pts.
Grammatical rules: /L/ marking verbs in different TAM constructions (1 pt.)

3.2.6. GURO (< SOUTHERN)
Tonal contrasts: /H/ vs. /M/ vs. /L/ vs. Rising vs. Falling (5 pts.)
Paradigmatic complexity score: 5 pts.
Automatic rules: 1) voiceless consonants raise the tones considerably; 2) voiced consonants lower the tones considerably; 3) downdrift (3 pts.)
Non-automatic rules: 1) nouns form mobile paradigms where the first tone of the word depends on the tone of the preceding word => ×3; 2) verbs form separate mobile paradigms different from those of nouns => ×3 (verbs) (6 pts.)
Syntagmatic complexity score: 3+6=9 pts.
Grammatical rules: 1) nouns form various tonal classes according to their morphological tonal behavior => ×3; 2) verbs form various tonal classes (not identical to those for nouns) according to their morphological tonal behavior => ×3 (6 pts.)

3.3. LANGUAGES WITH 4 LEVELS CONTRASTED

3.3.1. YAURE (< SOUTHERN)
Tonal contrasts: /eH/ vs. /H/ vs. /L/ vs. /eL/ (4 pts.)
Paradigmatic complexity score: 4 pts.
Automatic rules: 1) L → eHL / eH__eH, eH__H; 2) L → eH / eH__L, eH__eL, eH__##; 3) eL → eHeL / eH__eH, eH__H, eH__L; 4) eL → eH / eH__eL, eH__##; 5) a group of /eH/ nouns block rules 1)-4) when standing in left context; 6) voiced consonants block rules 1)-4); 7) eL → HeL / H__H, H__L; 8) eL → H / H__eL, H__##; 9) LeH + L → L + eH/eHL (cf. rules 1)-2)); 10) eLH + L → eL + eH/eHL (cf. rules 3)-4)) (10 pts.)
Non-automatic rules: no?
Syntagmatic complexity score: 10+0=10 pts.
Grammatical rules: 1) /L/ marking verbs in Negative Imperfective; 2) verbs form 7 tonal classes according to their morphological tonal behavior in Perfective and Imperfective, c.f. Appendix 3 => ×3 (4 pts.)

3.3.2. TURA (< SOUTHERN)
Tonal contrasts: /eH/ vs. /H/ vs. /L/ vs. /eL/ (4 pts.)
Paradigmatic complexity score: 4 pts.
Automatic rules: 1) H → L / __## (1 pt.)
Non-automatic rules: 1) eH → H / eL__ inside phonological words (1 pt.)
Syntagmatic complexity score: 1+1=2 pts.
Grammatical rules: 1) /eL/ marking the second component of a compound; 2) /eL/ marking verbs in some constructions; 3) /eL/ marking nominalizations with postverbal arguments; 4) /H/ marking verbs in different TAM constructions (4 pts.)

3.3.3. GBAN (< SOUTHERN)
Tonal contrasts: /eH/ vs. /H/ vs. /L/ vs. /eL/ vs. /eLeH/ vs. /eLH/, also lexical (eL) (7 pts.)
Paradigmatic complexity score: 7 pts.

Automatic rules: no
Non-automatic rules: no
Syntagmatic complexity score: 0 pts.
Grammatical rules: 1) /eL/ →/H/, /L/ → /eH/ in the Past tense => ×2; 2) an operation of tone spreading on verb in Imperfective; 3) /eL/ marking verbs in non-distant Past; 4) /eLH/ marking verbs in distant Past (5 pts.)

3.3.4. KLA-DAN (< SOUTHERN)
Tonal contrasts: /eH/ vs. /H/ vs. /L/ vs. /eL/ (4 pts.)
Paradigmatic complexity score: 4 pts.
Automatic rules: no
Non-automatic rules: no
Syntagmatic complexity score: 0 pts.
Grammatical rules: 1) /eL/ marking verbs in Neutral aspect, Retrospective construction, and Future; 2) /L/ marking verb in conjoint Neutral aspect and Retrospective construction, verbs make 3 tonal classes => ×3; 3) /eL/ suffix marking Infinitive (5 pts.)

3.4. LANGUAGES WITH 5 LEVELS CONTRASTED

3.4.1. EASTERN DAN (< SOUTHERN)
Tonal contrasts: /eH/ vs. /H/ vs. /M/ vs. /L/ vs. /eL/ vs. /HeL/ vs. /MeL/ vs. /eHeL/ (8 pts.)
Paradigmatic complexity score: 8 pts.
Automatic rules: 1) HeL → HL / __L; 2) HeL → HM / __M (2 pts.)
Non-automatic rules: no
Syntagmatic complexity score: 2+0=2 pts.
Grammatical rules: 1) /eL/ on nouns in some possessive constructions; 2) /eL/ on verbs in Neutral aspect; 3) verbs make 14 classes according to their tonal behavior in conjoint construction => ×3; 4) /eL/ suffix marking Infinitive (6 pts.)

4. RESULTS. Table 3 summarizes the scores of the languages from the sample.

First of all, we can see that languages strongly differ in their total tonal complexity (the first column) which is a sum of paradigmatic and syntagmatic complexity (the second and the third columns respectively).

We would like to compare overall scores for syntagmatic and paradigmatic complexity to see if there is any correlation between these properties. However, simple tests show that there is a weak negative correlation between the two variables which is statistically insignificant: Pearson's r = -0.304, p = 0.206, Spearman's r_s = -0.297, p = 0.217 (p > 0.05 in both cases). This means that at least in the Mande languages from this sample there is no correlation between the number of contrasts and the number of tonal rules.

Interestingly, a moderately strong and statistically significant positive correlation exists between paradigmatic complexity and tonal morphology (the number of grammatical rules): Pearson's r = 0.611, p = 0.005, Spearman's r_s = 0.519, p = 0.023 (p < 0.05 in both cases).

N	Languages	Total tonal complexity	Paradigmatic complexity	Syntagmatic complexity	Grammatical tones
1	Bambara	9	3	6	1
2	Koro	16	3	13	1
3	Niokolo Maninka	8	3	5	0
4	Kakabe	5	2	3	0
5	Vai	5	2	3	3
6	Mende	6	2	4	2
7	Looma	14	2	12	2
8	G. Kpelle	10	3	7	2
9	L. Kpelle	10	4	6	2
10	Dzuun	6	4	2	0
11	Mano	4	3	1	6
12	Mwan	6	3	3	2
13	Beng	10	3	7	1
14	Guro	14	5	9	6
15	Yaure	14	4	10	4
16	Tura	6	4	2	4
17	Gban	7	7	0	5
18	Kla-Dan	4	4	0	5
19	Eastern Dan	10	8	2	6

TABLE 3. Tonal complexity in Mande

A closer look at Table 3 shows that languages with lower scores for paradigmatic complexity tend to have few or no grammatical rules while languages with more complex contrasts have more complex tonal morphology. It seems that a positive correlation between the number of contrasts and the complexity of tonal morphology can be explained by connecting the well-known facts that, first, tonal morphemes often originate from loss of affixal segments (Hyman 1978) and, second, tonal contrasts originate from loss of segments (Hombert 1978). Thus languages with more contrasts are likely to have lost more segments including affixes and so they are likely to have more complex tonal morphology. To test this hypothesis we should prove that languages with more contrasts and more tonal morphology tend to have fewer segmental affixes (or that they have fewer diachronically "old" affixes), but this goes beyond the scope of the present paper.

5. CONCLUSION. In the above sections I have discussed some of the issues involved in the notion of tonal complexity and its evaluation providing guidelines for researchers work-

ing on tonal languages. I have applied my methodology in a test case involving the Mande languages.

Tonal systems are comprised of phonemic contrasts and surface rules. Both aspects have to be studied when documenting a tonal language. I suggest a distinction between paradigmatic, or inventory complexity, and syntagmatic, or rule complexity. The study of tonal complexity provided thus far by Maddieson (2005, 2011) concerns only paradigmatic complexity (the number of contrasts) which does not seem to be sufficient in evaluating the overall complexity of a tonal system. At the same time phonologists generally believe that languages with larger number of contrasts have fewer tonal rules and vice versa. This can be reformulated as tonal equi-complexity hypothesis: paradigmatic complexity correlates negatively with syntagmatic complexity.

I tested the tonal equi-complexity hypothesis on Mande languages whose level contrasts, ranging from 2 to 5, provide a good testing ground. Following the methodology discussed in detail in section 2, I evaluated tonal complexity quantitatively counting the number of contrasts and the number of different kinds of rules.

Languages from my sample show no evidence of equi-complexity in tonal systems. This is not very surprising though: even if we expect any phonological trade-offs in languages as suggested and tested by Maddieson (2005, 2006, 2007), then the compensation may occur in some other phonological domains, e.g. in vowel or consonant inventories, syllable structure etc.

Finally, an interesting correlation found in my data is between the number of contrasts and the number of grammatical tonal rules (i.e. those cases when tones change meaningfully). Languages with more contrasts tend to have more grammatical tones. A possible explanation is that tonal contrasts and tonal morphemes tend to appear as a result of segmental loss, so the two phenomena are likely to accompany each other.

APPENDIX 1. TONAL RULES IN LOOMA. The rules applied to different syntactic groups in Looma are given in the order of their application in Table 4 below. The rule numbering shows their similarity among different syntactic groups and not their order.

Noun + Attribute	NounGEN + Noun (alienable possession)	NounGEN + Noun (inalienable possession)	Direct object + Verb
gùlù 'stick', *nɔ̀wɔ̀* 'dirty', *i* – definite suffix	*nà* 'my' (for alienable poss.) *sáyà* 'sheep', *i* – definite suffix	*nɩ̀ká* 'cow', *wɔ̀wɔ̀* 'leg', *i* – definite suffix	*gìlè* 'dog', *sɔ̀* 'catch' *su* – Imperfective suffix *i* – definite suffix
Grammatical Rule 1: Attribute gets grammatical /L/ (coinciding with lexical /L/ in the example): * *gùlù nɔ̀wɔ̀-i*	Grammatical Rule 2: The possessed NP gets grammatical /H/: * *nà sáyái*	Non-automatic Rule 1: Tone of the possessed NP is spread on the suffix: * *nɩ̀ká wɔ̀wɔ́i*	Non-automatic Rule 1: Tone of the verb is spread on the suffix; tone of the noun is spread on the suffix: * *gìlèi sòsù*
Non-automatic Rule 1: Tone of the attribute is spread on the suffix: * *gùlù nɔ̀wɔ̀-i*	Non-automatic Rule 1: Tone of the possessed noun is spread on the suffix: * *nà sáyái*	Non-automatic Rule 5: Tone of the possessor is spread on the possessed NP, but not on the suffix: * *nɩ̀ká wɔ́wɔ́i*	Non-automatic Rule 5: Tone of the noun spreads on the verb, but not on the suffix: * *gìlèi sòsù*
Non-automatic Rule 2: Lexical tone of the Noun spreads on the Attribute and the suffix: * *gùlù nɔ̀wɔ̀-i*	Non-automatic Rule 5: Tone of the pronoun spreads on the NPs, but not on the suffix: * *nà sáyài*	Non-automatic Rule 7: If the possessed NP is autosemantic, the new tone of the possessed NP is spread on the suffix (is not applied to our example).	Non-automatic Rule 3: A prefixal referential article *ŋ́* is added to the noun, its /H/ spreads on the noun and the article: * *gìlèi sòsù*
Non-automatic Rule 3: A prefixal referential article *ŋ́* is added to the noun, its /H/ spreads on the noun: * *gùlù nɔ̀wɔ̀i*	Non-automatic Rule 6: High tone of the suffix is spread on the last syllable of the noun: => *nà sáyái* 'my sheep' NB: not all nouns => ×2	Non-automatic Rule 3: A prefixal referential article *ŋ́* is added to the first noun (its tone coincides with that of the first noun in the example): => *nɩ̀ká wɔ̀wɔ́i* 'the cow's leg'	Non-automatic Rule 8: The new /H/ of the direct object is spread on the first syllable of the verb: => *gìléi sósù* 'to catch a dog' NB: not all nouns => ×2
Non-automatic Rule 4: /H/ of the noun spreads to the first syllable of the adjective, because the noun belongs to a special tonal cl=ass. => *gùlù nɔ́wɔ̀i* 'dirty stick' NB: not all nouns => ×2			

(after Mishchenko (2009) with my visual representation and rule numbering)

APPENDIX 2. PATTERNS OF TONAL BEHAVIOR IN MWAN. According to Perekhval-skaya (2006, ms.), there are three patterns of tonal behavior in Mwan labeled Constant, Mobile and Coordinative pattern. Importantly, each class includes words with different lexical tones. Words following the three patterns differ in their tonal behavior after /H/, /M/ and /L/ tones.

Pattern	Left context	Tone on the first mora of the word	Examples	Comment
Constant *gbɛ̄* 'hand'	/H/	LEXICAL	*ŋ́ gbɛ̄* 'my hand'	All word classes
	/M/	LEXICAL	*lē gbɛ̄* 'woman's hand'	
	/L/	LEXICAL	*ŋ́ drúānɛ̀ gbɛ̄* 'my nephew's hand'	
Mobile *yɔ̀ɔ̄* 'bad'	/H/	/H/	*dàwlí yɔ́ɔ̄* 'bad trick'	Content words classes, postpositions, negation marker
	/M/	LEXICAL	*yrē yɔ̀ɔ̄* 'bad place'	
	/L/	/H/	*zà yɔ́ɔ̄* 'bad business'	
Coordinative *yàà* 'saw' (Perfective from *yē* 'to see' with mobile pattern)	/H/	/H/	*Jàrà kpɛ́ yáà* 'A lion has seen a roe'	Some nouns with low lexical tone of the first foot, some verbs in Perfective, postposition *là* 'under'
	/M/	/L/	*Jàrà māā yàà* 'A lion has seen a chicken'	
	/L/	/L/	*Jàrà zɔ̀ yàà* 'A lion has seen a pangolin'	

APPENDIX 3. TONAL MORPHOLOGY OF VERBS IN YAURE. According to Kushnir (p.c.), in Yaure verbs form several classes according to their patterns of tonal change in Perfective and Imperfective.

Lexical structure	Perfective	Imperfective
á	á	a̋
à	á	à
ä	ä	à
a̋(l)a̋	à(l)à	a̋(l)a̋
àa̋	àà	àa̋
à(l)à	à(l)à	à(l)à
ä(l)á	à(l)à	ä(l)ä

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