How Rhythm and Timbre Encode Mooré Language in Bendré Drummed Speech

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Abstract

Human languages have the flexibility to be acoustically adapted to the context of communication, such as in shouting or whispering. Drummed forms of languages represent one of the most extreme natural expressions of such speech adaptability. A large amount of research has been conducted on drummed languages in anthropology or linguistics, particularly in West African societies. However, in spite of the clearly rhythmic nature of drumming, previous studies have largely neglected exploring systematically the role of speech rhythm. Here, we explore a unique corpus of the Bendré drummed speech form of the Mossi people, transcribed published in the 80's by the anthropologist Kawada Junzo. The analysis of this large database in Mooré language reveals that the rhythmic units encoded in the length of pauses between drumbeats match more closely with vowel-to-vowel intervals than with syllable parsing. Meanwhile, we confirm for the first time a result found recently on the drummed speech tradition of the Bora Amazonian language. However, the complex acoustic structure of the Bendré skin drum required much more attention than the simple two pitch hollow log drum of the Bora. Thus, we also present here results on how drummed Bendré timbre encodes tones of Mooré language.

Index Terms: drummed speech, mooré language, language surrogates, speech rhythm, Bendré

1. Introduction

1.1. Drummed languages in general

Drummed speech is a traditional practice found in several languages around the world that consists in adapting and reducing the phonetics of spoken speech into sounds produced with drums to enable the transmission of verbal messages to a general audience and often over long distances. A wide variety of messages are communicated through this special speech modality which has been sometimes also called 'drummed surrogate', 'drummed substitute' or 'drummed abridgement' of language [1][2][3]. Drummed speech is rarely used for dialogs in the sense of what is commonly practiced in spoken speech, but is better adapted for short two-way exchanges between drummers or for one-way public announces (give instructions, recite texts, or call someone). Most strikingly, rhythms and melodies of speech are transformed into sequences of drumbeats which remain comprehensible to the trained because they recall key salient linguistic cues of spoken sentences [2][4][5]. Among natural speech encoding systems, drummed speech employs the most radical acoustic reduction in all three main dimensions: frequency, amplitude and time [6]. Acoustically, drumming is made of sound bursts that concentrate most of the energy in low frequencies. Drummed signals exploit the natural bio-acoustic properties of percussions for optimal sound propagation in natural environments. Depending of the type of drum, the percussive acoustic signals may have a clear pitch, such as for the hollow log slit drums of the Bora people of the Amazon [4][5], or not, such as for the Bendré skin drum of the Mossi people under study here (see Figure 1).

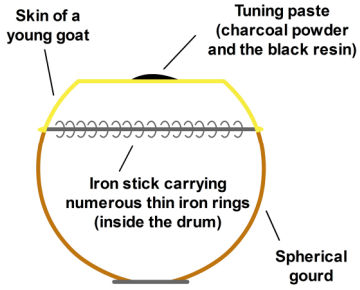

Figure 1: *Bendré drum.*

Drummed forms of languages have been documented in a wide diversity of languages in Africa, Asia, Oceania and South America. For example, an early collection of papers on this phenomenon [3] dealt with 18 different languages.

1.2. Coding speech with drums: the challenge of rhythm

Contextualization: A general characteristic of drummed phrases is that, to ease decoding, they are strongly contextualized through different means: reciting traditional text, singing lyrics, enphrasing in formulaic forms [2][7][5].

Frequency coding: Until now, drummed speech has been attested almost exclusively for tonal languages. Phonological tone patterns are rendered through different drummed frequencies (pitch or timbre). Register tones are generally represented by single beats, and contour tones on a single syllable may be rendered by a succession of two beats of different frequency levels [3][7].

Rhythm: In spite of the large amount of research that has been conducted on drummed languages so far, particularly in West African societies, very few studies explored systematically the relation between speech rhythm and the timing of beat sequences. Yet, the clearly rhythmic nature of drumming and the repeated affirmation of master drummers that they copy spoken speech motivate new investigations in this domain, all the more as the rhythmic organization of speech is a complex phenomenon and an area which remains the subject of extensive debate and experimental research.

Up to now, only few studies revealed the potential of drummed speech encoding to understand better speech

rhythm: one dealing with Akan of Africa [8], the other ones on Bora of Amazonia [4][5], and, to a lesser degree, some impressionistic approaches on Banda Linda of Africa [7]. Most notably, these studies show that inter-beat durations (IBDs) correlate with linguistic weights and represent basic rhythmic units of speech. Moreover, the latest findings on Bora drummed speech - the only ones based on a systematic statistical and phonetic analysis - show that weight distinctions are rather vowel-to-vowel intervals than syllables. Interestingly, such results are coherent with recent advances in language sciences which support the vowel-to-vowel (V-to-V) intervals as relevant units for phonetic duration [9] or with research in psycholinguistics on the notion of 'perceptual centre' (p-centre) [10] which is more closely aligned to the beginning of the vowel than the beginning of the syllable [11][12].

1.3. The aims of our study

The present study on Bendré Mossi drummed tradition of Mooré language was conducted in order to check whether these important results obtained with Bora can be confirmed on a very different language and with a much more acoustically complex drum. It is a necessary step to possibly generalize such results. We explore an extremely rare 30 min long corpus of the Bendré drummed speech form thanks to the invaluable published recordings and transcriptions made by the anthropologist Kawada Junzo [13][14]. By applying the same procedure of analysis as developed for the Manguaré drummed speech system of Bora people of West Amazon in previous studies [4][5], we also provide a comparison between both systems. Moreover, given the complex acoustic structure of the Bendré skin drum we also present here results on how drummed Bendré timbre encodes tones of Mooré language.

2. Bendré Drum and Mooré language

2.1. Mooré phonology

Mooré is the language of the Mossi people, it is spoken in different countries of West Africa, especially in Burkina Faso [15][16]. Mooré is part of the Voltaic language family and the corpus of the present study is based on the Tãnkʊdg dialect [13]. The transcriptions provided by Kawada relies on 17 phonemic consonants [b, d, f, g, h, k, l, m, n, p, r, s, t, v, w, y, z] where [w] and [y] are classified as semi-vowels according to [15][16] and 8 phonemic vowels [a, e, ɛ, i, ɪ, o, u, ʊ] some of which are nasalized [ã, ẽ, ĩ, õ, ũ]. Additionally, Mooré phonologically distinguishes short vs. long vowels, and long ones are written as sequences of two identical vowel symbols. The syllabic structure of Mooré language was described by Peterson [17]. Mooré is a tonal terracing language with two tones, High (H, eventually written H1 or H2 when terraced) and Low (L), carried by the nucleus of the syllable [17].

2.2. Mossi Bendré drumming

Bendré is coming from an old royal tradition of the ancient Mossi kingdoms in West Africa. As described by Kawada the Bendré drum that was documented in the corpus is made of a spherical gourd, covered with the skin of a young goat (Figure 1). Just under the skin, a wooden or an iron stick is fixed, carrying numerous thin iron rings. At the center of the surface, the player puts the tuning paste in a disk form [18]. The drum is struck with the fingers of both hands on different points on the surface. When the surface is tapped, the iron rings, under the skin, resound [18]. Generally, the Bendré is used to express verbal messages, especially to recite the dynastic genealogy of Tãnkʊdg (also written Tenkodogo), expressed in the form of maxims with abundant metaphors [18]. A Mossi Bendré player, distinguishes two kinds of sounds: Koë raaga (= men's voice) hard, dry and shrill and Koë yâanga (= mature women's voice) blunt, resonant and subdued [18]. From the Bendré corpus, we identified 5 main beat types which can be classified in two groups of timbres following its mean frequency centroid (FreqC), calculated here on 10 beats each: relatively High timbres (S,R), relatively Low timbres (B,T), and an additional special Muted beat (see Table 1).

Table 1: *Beat type of Bendré classification as a function of mean frequency Centroid (FreqC) and associated Timbre Class; the Muted tone (M) is special due to very weak amplitude and resonance.*

Type of beat	Name	Mean FreqC (Hz)	Timbre class
Slap	S	620	High
Rim tone (with metal rings)	R	372	High
Bass	B	198	Low
Tone	T	233	Low
Muted tone	M	233	-

3. Materials and methods

3.1. Materials

The materials analyzed here were collected during long term fieldwork in Burkina Faso and Ghana from 1963 to 1984 by Kawada [13],[14], and more particularly with one master drummer from south Mossi people of Tãnkʊdg region. The recorded audio version, made in 1975, contains together the recited dynastic ancestors' genealogy of Tãnkʊdg, in drummed and spoken forms [14]. For this first study, we focused only on the drummed form. It was transcribed in Mooré and French in [13]. The corpus contains 762 drummed phrases (composed by 30 sections of verses and refrains). Additionally, the tonal transcription of a large part of the corpus was published in [19]. These recordings, annotations and transcriptions represent an extremely rare documentation of a highly endangered oral patrimony in all Mossi kingdoms. This tradition already vanished in some regions and Kawada insists in that his work should contribute to apply to including Bendré tradition on pone of the Unesco Lists of Intangible Heritage.

As explained above, the Bendré corpus was based on a large traditional recited text with refrains. The most frequent words, appearing in these refrains, corresponded to stereotyped formulas with a particular status [18][19]. For this reason and because of their very high weight in statistical results, we decided to exclude them from our analysis, as was also done in the Bora drummed speech studies [4][5]. We also excluded drummed data with mismatching problems (in which the number of drumbeats did not match with the intended Mooré phrase due to 'slips of the drum') that were identified with a native speaker. Finally, the retained subcorpus contained 521 phrases, 1955 words, 3289 drummed beats associated to a phonemic content (of which 2944 had a tonal annotation as not all phrases had a tonal annotation in [19]). This corresponded to 1324 IBDs which could be measured

only on multisyllabic words (50% of the words are monosyllabic in this corpus).

3.2. Design and procedure

Our main objective was to explain the correspondence between spoken language units and the main rhythmic and frequency parameters conveyed by drummed Mooré.

Concerning rhythm, we looked for rhythmic units represented by the inter-beat durations (IBDs) in drummed messages, word internally. Following previous methods applied to Bora Manguaré [4][5], we associated each drummed IBD to the spoken phonemic content – made of Consonants (C) and Vowels (V) – corresponding either to syllabic intervals or to Vowel-to-Vowel intervals (V-to-V) of the linguistic transcription (Figure 2 and Figure 3). Of these two concurrent tested possibilities, the V-to-V parsing is less commonly used in linguistics than the syllable one. However, as already explained in the introduction, it is justified by the fact that vowel onsets play a crucial role in the perception of the 'beats' of spoken speech [5],[20]. Here, the reference for syllabic structure of Mooré language was taken in the linguistic description made by Peterson [17]. In the retained corpus, the most frequent syllable structures were CV, CVC, CVV and CVVC; whereas the most frequent derived V-to-V structures were VC, VCC, VVC and VVCC. Finally, we statistically analyzed the variations in the qualitative IBD variable as a function these two alternative possibilities of phonemic structures. Details of each model are provided in the next section.

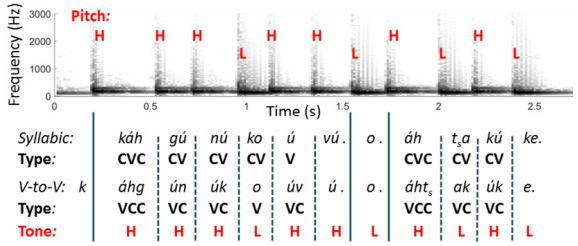

Figure 2: *Spectrogram of drummed signal of Manguaré: káhgúnúkoúvú o áhtsakúne (meaning 'I am finishing to drink cahuana')(adapted from[5]).*

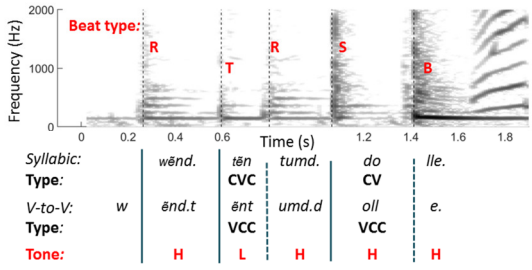

Figure 3: *Spectrogram of drummed and speech signal of Bendré: wẽnd tẽntumd dolle (meaning 'The beloved messager of God').*

For frequency coding, we associated each drum beat of Bendré (classified by type as presented in Table 1: S, R, B, T or M) to its tone in the linguistic transcription (Figure 2 and Figure 3). Next, we statistically analyzed the relation between the drum timbre to the vowel tone. We had a similar approach for Bora drummed speech with the important difference that the pairs of Bora hollow log drums produce 2 clearly different definite pitches to encode a two tone language (see Figure 2). Here, the frequency association between linguistic tone and the beats of the Bendré skin drum is much more challenging as it is based on a timbre with 4 different types of beats + a special muted one. Moreover, the tonal system of the language is terracing.

4. Results

4.1. Rhythmic structure

The Figure 4 compares the statistical results of the IBDs as a function of syllable types and V-to-V types. We observed differences between the two sequencing models only in the case CVVC versus VVCC. Indeed, 98% of CV types in the syllabic model become VC types in V-to-V model. Similarly, 91% of CVC syllable types become VCC V-to-V types, and 99% of CVV syllable types become VVC V-to-V types; but only 31% of CVVC syllable become VVCC V-to-V.

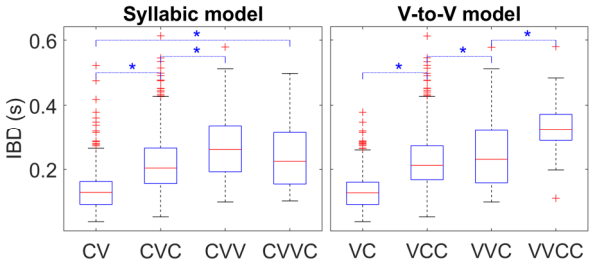

Figure 4: *Distribution IBDs as a function of syllable types and V-to-V types.*

To find out which rhythmic units are represented in drummed Bendré interbeat durations, we evaluated statistically which kind of hypothesis (syllable versus V-to-V; Figure 4) explains best the IBD temporal distribution by constructing two different linear models with IBDs as predictor variable and phonemic structures as a response variable (model 1: syllabic structures; model 2: V-to-V structures) using the fitglm function to perform linear analyses with Matlab [21]. Visual inspection of residual plots of both models did not reveal any obvious deviations from homoscedasticity or normality, nor the presence of influential outliers.

Comparison of the two models: model 1 ($F= 189$, $p <0.001$) has an adjusted R-square value of 0.3302; model 2 ($F= 247$, $p <0.001$) has an adjusted R-square value of 0. 3816.

Next, we performed multiple comparisons. For each of the models for which it was needed, the multiple comparisons were done with Hothorn et al.'s method [22] using the function multcompare from Matlab. Multiple comparisons between different modalities of syllable types showed that the CV type was significantly different in duration from the others, while CVVC type was not significantly different from CVC type and CVV type. As a consequence, the IBD scale for syllable structures is as follows: CV < {CVC, CVV, CVVC}. By contrast, multiple comparisons between different modalities of V-to-V types showed that all types of phonemes were significantly different in duration from each other's. As a consequence, the IBD scale for V-to-V structures is as follows: VC < VCC< VVC < VVCC.

4.2. Tone and Pitch

The statistical distribution of the main drummed beat types identified in Table 1 (B, T, R, S and the special muted tone M) was presented as a function of two parameters (Figure 5): (i) the associated tone transcriptions - either H (including H1 and H2) or L; and (ii) the position of the corresponding syllable in the phrase (the last syllable was analyzed separately, following an observation of Kawada [19] concerning final Bendré strokes which have a special behavior as they are very often Low).

We found that the H (including H1 and H2) or L linguistic tone values matched respectively with 77% of high-timbre drummed beats {R,S} and 89% of low-timbre beats {B, T} in the drummed signal in cases of non-final positions of the phrases (see Figure 5, left); whereas, the H (including H1 and H2) or L linguistic tone values matched respectively with only 26% of high-timbre drummed beats and 90 % of low-timbre beats {B, T} in the drummed signal in final positions of the phrases (see Figure 5, right).

The low result of 26% for High tones can be explained by the fact that final syllables of phrases in Bendré are very often beaten as a B (see Figure 3), probably as a marker of the end of the recited phrase (Kawada [19] speaks of a stylistic effect).

Another rather surprising result is the 77% for H tones matching with High beaten timbres. Interestingly, this could be partly explained by the fact that we also observe that H1 and H2 (isolated from H) matched only with 67% of high timbre in non-final positions. This is congruent with the surface terracing properties of the tonal Mooré system [17], which are specifically signaled by the H1 and H2 tonal transcriptions.

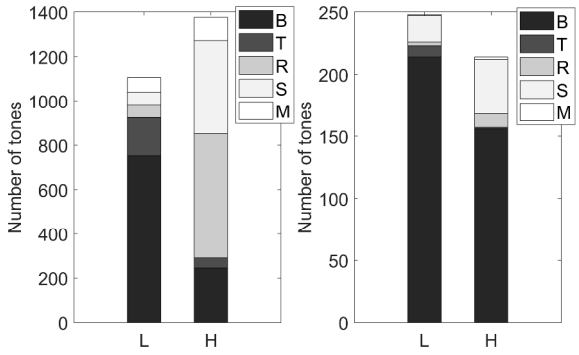

Figure 5: *beat types of drum by tone transcription; (left) first and middle syllables of the phrase; (right) last syllables of the phrase.*

5. Discussion

Our study explored the matching between spoken Mooré language units and the main rhythmic and frequency parameters conveyed by drummed Bendré Mossi tradition.

Regarding rhythm, aligning beats with syllables leads to group inter-beat durations (IBDs) in a way that does not provide statistical difference between three syllable types of Mooré and thus results in a IBD scale for syllable types that is of the form: CV< {CVC, CVV, CVVC}. Only CV syllable type is different from the others. This scale thus suggests that heavy syllables would be longer. However, in this hypothesis, adding a Consonant to CVV would not increase duration of a syllable, which not an expected result. On the contrary, aligning beats with the onset of the vowels leads to an IBD scale of the form VC < VCC< VVC < VVCC where four rhythmic units are statistically different. This scale reflects effects of both vowel length (VVC longer than VC) and of the number of consonants (VCC longer than VC and VVCC longer than VCC). Moreover, it is possible to compare models at another level by using the adjusted R-square values obtained for each model, as they indicate the part of variation in the IBD variable that is explained by the explanatory variables of each model, taking into account their number of parameters. Here we very clearly found R-square(Syllabic)<R-square(V-to-V).

Taken together, these findings constitute evidence that the rhythmic units encoded in drummed Mooré with Bendré correspond more closely to V-to-V intervals (as shown in Figure 4) rather than to syllables. This is coherent with the first results found in this topic in Bora language on Manguaré drums [4][5]. Moreover, just like for Bora, Mooré V-to-V drummed distinct rhythmic units are differentiated by around 20 ms or more, which is within the resolution of differentiation for the human perceptual and cognitive systems [5].

Regarding tone, the Mossi Bendré skin drum allows a higher diversity of beat types than the Bora Manguaré simple hollow log drum which employs only two pitches (one of each drum) to code the two-tone Bora language [4][5]. Indeed, Mooré - a two tone and terracing language - is here coded by several Bendré timbres, much more complex to produce and to analyze acoustically. However we managed to explain and summarize in section 4.2 and Figure 5 how this frequency coding works, beginning to even unravel the terracing complexity of the language.

6. Conclusions

The present study on Bendré African drummed tradition encoding Mooré language confirms for the first time important results dealing with speech rhythm obtained recently on Bora Amazonian drummed speech. These show the importance of non-isochronous rhythmic structure embedded in speech. This confirmation opens the perspective to generalize these findings, all the more as they were found on a very different language encoded with a drum with a much higher diversity of beat types. These results will thus fuel the large debate supporting the status of the vowel-to-vowel (V-to-V) intervals (or weights) as relevant units for phonetic duration [9], reinforcing results found otherwise in psycholinguistics and using the notion of 'perceptual centre' (p-centre) [10]. Concerning Bendré, the perspective is now to provide a comparison with recordings of Mooré spoken speech.

7. Acknowledgements

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