The contribution of the kymograph to the description of African languages

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The kymograph, one of the main devices used in early experimental phonetics, was quickly exploited to describe the sounds of languages in sub-Saharan Africa. By 1926, Doke used this device in its phonetics Zulu, to objectify the description of the main sounds of this language: vowels with epiglottal friction; the difference between aspirated and non-aspirated explosive consonants and consonants he describes as ejectives explosives; the three types alveolar laterals (voiced, voiceless and voiceless lateral); the duration of vowels and the different levels of tones. Doke shows that these are the plots of kymograph which to observe a similarity between the consonant bilabial implosive [ɓ] and clicks. The kymograph plots, presented in Figure 1 show indeed clearly a negative airflow at the release of the implosive and of the dental click contrasting with the positive flow observed after a bilabial explosive consonant (Doke 1926: 60).

![Kymograph plots of Zulu showing the airflow at the release of a click [ya] described as dental voiced by Doke (1926), a bilabial implosive [ɓa] and explosive [ba]. (The symbol of the click is now [] in the transcription of the International Phonetic Association), Doke (1926).](image)

**Figure 1.** Kymograph plots of Zulu showing the airflow at the release of a click [ya] described as dental voiced by Doke (1926), a bilabial implosive [ɓa] and explosive [ba]. (The symbol of the click is now [] in the transcription of the International Phonetic Association), Doke (1926).

The kymograph was also employed by Westerman and Ward (1933) to show the difference between explosives and implosives in Igbo and Efik. Besides the difference between the two types of bilabials consonants, already highlighted by Doke, they provide examples of the labio-velar consonants [kp] for which there can be a negative flow upon release. These data show a difference between the release of the consonant [kp] in Efik, which is followed by a positive airflow, and Igbo that does not show the positive flow and is described as implosive.
Doke (1931) in his remarkable study on the comparative phonetics of Shona still makes a systematic use of the kymograph to describe the consonants of this language. The combination of nasal and buccals plots or of those with and laryngeal vibration plots allows it to establish the presence or absence of voicing and the boundary between the nasal and oral parts in complex consonants.

A document, unpublished and very interesting (provided by the late Anthony Traill), where Pienaar uses the kymograph, discusses the types of release of the Zulu clicks (Figure 2). Pienaar was a professor of speech therapy at the University of Witwatersrand in the years 1930-1940. He interacted and worked with Doke and created a phonetics laboratory in which students received training techniques, which would be called instrumental phonetics today. Doke and Pienaar would have used the material to make its measures on the airflow of clicks when working with Zulu and Bushman. In his notes, Pienaar describes three phases in the production of clicks: the production, the acoustic result of the anterior release and what he called other members of the click’s composition. For Pienaar, clicks are actually compounds phonemes consisting in one or more acoustically different speech sounds to be evaluated ‘monophonically’. The first part of the phoneme is the actual suction, while the second may have different acoustic qualities other than the sounds of relaxation and friction. The sound of the suction release is generally described as the click itself. It is usually identified from where the anterior release was made. Pienaar describes the following types of clicks: (1) bilabial or (2) a labio-dental variant; (3) inter-dental, a variant of (4) dental; (5) alveolar; (6) prepalatal; (7); alveolar or prepalatal as (5 and 6), but with a lateral release and (8) retroflex. Each of these types of clicks can be followed in various ways to release the velar closure. These are illustrated in Figure 2 which shows, combining oral flow plots (M) and the vibration of the larynx (L): a voiceless velar stop (kymograph plot –from now on Tk-I); an aspirated voiceless velar stop (Tk II); a voiceless velar affricate (Tk III); a voiced velar stop semi-plosive (Tk IV and V); a voiceless velar stop semi-plosive (Tk VI); a velar ejective (Tk IX); a velar affricate ejective (Tk X). The plots (Tk VII) (Tk XI) show clicks accompanied by a glottal fricative and a glottal stop. Table 1 summarizes the data.

**Table 1.** Words analyzed by Pienaar in his study of the posterior releases of Zulu clicks. The numbers correspond to those in Figure 2.

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<td>26</td>
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Pienaar documents are among the first to demonstrate the presence of the two parts of clicks on an experimental basis. His study of the types of posterior releases shows a remarkable understanding of the phenomenon and prefigures the concerns of contemporary researchers.

Beach (1936) in its phonetics of the Hottentot (Nama) language emphasizes the usefulness of the kymograph to study the problems of nasalization, duration and intonation. Some selected plots clearly highlight the clicks of the language and the issues discussed in his treatise.
The identification of tones is fundamental to understand the phonetics of Sub-Saharan languages. The description of this phenomenon took some time before being controlled and clearly illustrates the difficulties researchers had to describe the phenomenon experimentally, in a suitable framework. The famous Laman study (1922) on the musical accent and intonation in Kongo is one of the first systematic work on tone. The satisfactory instrumental treatment of tones, easy as it may seem, has been realized in the second half of the twentieth century. The main problem was to clearly identify the categories of tones -the tonemes- and then process their achievements and phonetic variations. It seems that the first to use the term toneme treatment Beach (1924), as emphasized by Doke (1926: 198).

The problem may seem trivial today, but it illustrates the relationship between the abstract aspects (phonological) and concrete (phonetic) in the study of speech. Even if the processing
of tones by Doke (1926) and Beach (1936) with the kymograph has only historical interest, it is worth to describe it. This to understand the conceptual difficulties that the researchers had in the early twentieth century, when working on tone languages.

Doke distinguished what he called the characteristic and significant tones. He viewed the former as a method to group the succession of musical heights characterizing a particular language or group of languages. The latter held an active role in grammatical meaning of language and were a way to distinguish different meanings of the words that were phonetically similar. Doke identified 9 tones in Zulu. We should not to believe that his understanding of tone was naive, as shown in the following statement: "Only a comprehensive study to discover the true phonemes could reduce my system to less than 9 tones for recording " (Doke 1926: 199). Doke adds that it is not the absolute height that counts, but the relative height, the extent of intervals. To measure 9 tones he identified in Zulu, he used the following method: a kymograph recorded the trace of an electric tuning fork that produced 100 vibrations per second. A native speaker, in a mask connected to a kymograph, then produced the 9 tones. The plots of these recordings were then placed below those of the tuning fork. The number of vibrations of each of these ‘tonal curves’ corresponding to the length of 100 vibration of the tuning fork was then counted and the results compared to the table of notes of the chromatic scale of Rayleigh (1877). Figure 3 illustrates the result of this process. To transcribe the tones in relation to a text, he then used a number system, which ranged from 1 (highest tone) to 9 (lowest tone). The modulated tones were transcribed with a line between the two levels.

Doke (1926) also used the kymograph as a support to the study of tones. This topic is also a highly developed phonetic point of the Hottentot. However, no plot is given in his description, he mentions that it is because of cost of publication and space prevented him from publishing these kymograph plots. Anyway, Beach methodology is interesting to describe, for it differs from that of Doke and because it shows the concerns of these researchers to put the experimental data in an appropriate conceptual framework. Data were recorded on an Edison
phonograph. Recordings were standardized to the phonetic analysis using a tuning fork that Beach called again philharmonic 3. (Here Beach probably refers to the 439 Hz as it was defined by the Royal Philharmonic Society in 1896, since it was not until 1939 that the International Association stared the measure, known as the concert A, at 440 Hz). At the beginning of each record, before the speaker told a Hottentot story, Beach made the tuning fork vibrate in the phonograph and also sang an A in the recorder. This A was the reference height. Subsequently, when records were used on different phonographs, for tonetic analyzes, the reference height reproduced at the beginning of the recordings was tested against a tuning fork giving the Philharmonic A. If the heights of the recording and the pitch were different from each other, the speed of the phonograph was then adjusted until the reference height matched the tuning fork. When this was done, the tone of the record was identical to that of the speaker when the recording was made. Beach then mentions the existence of devices for the automatic transfer of the gramophone curves to smoked paper, in order to realize the analysis of tone curves with mathematical accuracy. Beach, for reasons of time, apparently did not made much use of the kymograph plots for his tones transcriptions. He used what he calls 'the method of the ear' for this, that is to say, an auditive transcription. Beach transcriptions were then set on a musical score making reference to the 7 types of tones he identified for Hottentot. This is illustrated in Figure 4, which shows the transcription of a piece of text, and the reference heights identified by Beach, for tones in Hottentot.

Figure 4. Transcription of the toneme X (rising high) identified in the Korana dialect of Nama by Beach. The Reference lines of the musical score correspond to the notes (G), (B), (D), (F), (A), C (C) and (E). The transcription shows a nominal root and a verbal root starting by the toneme 'X, Beach (1936)

The way Beach transcribed tones is also interesting because it allows to introduce the discussion on the issue of identification of what would now be called phonological tones. This is illustrated in the criticism Beach (1936) addresses to Doke (1926) and Tucker (1929) who are criticized for their misuse of the term toneme. For Beach (1936: 127) "A tone marks system must have as a basis the same principle as the phone system marks (phonetic symbols). In the same way that the phonetic transcription depends on the phonemic principle the tonetic transcription should depend on the tonemic principle ".

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Doke (1926: 198), meanwhile, distinguished between: phonetics that deals with phones, groups of phones and phonemes and tonetic that handles tones, tonal groups and tonemes. It is not difficult to realize that the opposition between Doke and Beach come from the fact that the second identifies a phonological level, where the former does not. Doke, and to some extent Tucker faced representational level problems (phonetics, phonology, morphophonological) that were not properly identified in the Bantu languages and still pose problems for bantu specialists. Again, it will take decades to realize that a number of pitch variations are not significant but are linguistically due to mechanical linkages that occur in the process of speech production (Ladefoged 1968).

References

Laman, K. E., 1922, «The musical accent and intonation in the Kongo Language», Stockholm.