AN ARTICULATORY DESCRIPTION OF CLICKS BY MEANS OF ELECTROMAGNETIC ARTICULOGRAPHY

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ABSTRACT

In this paper an articulatory description of two types of clicks which are used in the Bantu language Xhosa is presented. Although in some utterances the coils caused inadequate affrication, the main elements of the click sounds could be traced, e.g. the backward movement of the tongue body during the occlusion of [!] followed by a very fast downward movement of the tongue tip after the anterior release attaining a maximum velocity of more than three times the velocity for the tongue tip opening gesture of [t].

INTRODUCTION

Previous work on Southern African click sounds was based mainly on perceptive and acoustic analyses. So far there are only relatively few physiological data. Traill (cf. [1]) presents cineradiographic and electropalatographic data which allow for a detailed description of the articulation and a corresponding classification of the different click types. Electromagnetic Articulography (EMA) has not been used before to analyse the articulatory movements during the production of click sounds.

In producing a click sound the tongue has to form two closures: at the front and at the back of the tongue so that a body of air is enclosed in between. By a downward movement of the mid-tongue while tongue tip and dorsum maintaining contact to the roof of the mouth the air in the cavity is rarefied and a suction effect is created. Now the forward closure is released and air rushes into the mouth, producing a click sound. Then the backward closure is released (called the *click accompaniment*, cf. [2]) which does not always produce a perceptible sound or noise.

The Bantu language Xhosa uses three types of clicks which can be classified (according to the terminology of [2]) as the dental click, phonetically transcribed as [|], and the (alveo-) palatal click [!] and the lateral click [||]. However, there is a controversy on the exact places of articulation. In the present study we only examined the dental [|] and the (alveo-) palatal click [!] because Electromagnetic Articulography permits the registration of movements in the mid-sagittal plane of the oral tract only so that it was not possible to investigate the movements with laterals.

The present study is a first attempt to use EMA for describing the sequence of events during the production of click sounds.

METHODS

EMA allows for registration of movements inside the oral cavity with reasonable spatial and temporal resolution. Thus the high articulatory velocities occurring during click sound production can be registered.

In the present experiment 5 sensor coils were placed on the following positions: two reference coils on the nasion and below the lower incisors to record the movements of the head and the jaw as well as three coils on the tongue: 5 mm behind the tip of the tongue (TT), in the place of articulation of [k] in [aka] (determined by a colouring test) on the tongue dorsum (TD) and in the middle betweeen TT and TD. The kinematic recordings were made with a sampling rate of 200 Hz. Simultaneously to the articulatory recordings the acoustic signal was digitally recorded.

In addition to the click sounds the alveolar stop [t] and the dorsal stop [k] were used as reference. Every target sound was embedded in a nonsense syllable VCV (with V = [a]) and had to be produced in a target phrase: *Ndithi a_a ngoku* (I am saying a_a now). Ten tokens of each stimulus were visually presented in randomized order. Since the subject had some initial difficulties producing the palatal click with the coils attached to the tongue the sentence with the palatal click target was produced another 20 times. The sentences were produced by one male subject who learned Xhosa as a third language and has been staying in a Xhosa speaking area for the last 23 years (one of the authors, J.R.).

Since in some utterances speech was obviously disturbed by the coils leading to inadequate affrication an auditive assessment was carried out by the speaker and only those tokens were selected for further analysis which clearly sounded like adequate click sounds. In addition some utterances had to be rejected because the TD coil which obviously interfered with the click production got loose. In the end 6 tokens of [aka] and 7 tokens of [ata], [a|a] and [a!a] were included in the kinematic analysis.

ARTICULATORY DESCRIPTION

The data is not sufficient for a detailed quantitative analysis. However, a close examination of the x/y-trajectories of the tongue sensors together with the acoustic signal during the production of the sequence [a!a] provides the following articulatory description: All three tongue sensors moved simultaneously from the back, low position for the first [a] upwards and to the front and got in contact to the anterior and posterior parts of the palate. In the middle of the occlusion the highest position of all three tongue sensors was achieved. During the last part of the closure the tongue dorsum started moving downward while the mid-tongue was pulled further up and further back, moving behind the position of the tongue dorsum, which must be interpreted as a retroflex movement. For this type of click a retroflex articulation has been reported elsewhere [2]. From its highest position at the palate the tongue tip then was released and performed a very fast (vertical) downward movement attaining a peak velocity of up to 1094 mm/sec. The release allowed air rushing into the mouth producing the characteristic click sound. After that the dorsal part of the tongue moved downward with a maximum velocity of 470 - 630 mm/sec. In contrast, the stop of the dorsal plosive [k], produced by the same subject, was released with a peak velocity of 149 to 200 mm/sec and the alveolar plosive sound [t] with 290 to 442 mm/sec.

DISCUSSION

By the application of Electromagnetic Electrography for the registration of the articulatory movements during the production of dental and palatal click sounds some technical problems appeared: Some click sounds were erroneously affricated because the articulation was deranged by the coils attached on the tongue. Furthermore, in some utterances the strong friction of the tongue against the palate removed the posterior receiver coil so that these recordings could not be analysed. Besides these technical problems the subject produced slightly hyperarticulated speech with slow overall speech rate, inter-word pauses and long stop closure times. Thus it might be the case that the observed click sounds were hyperarticulated, too. Nevertheless, the basic sequences of events could be traced and the high velocity peaks occcurring in click sound production could be registered by means of the applied method.

REFERENCES

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