UiT The Arctic University of Norway

Faculty of Humanities, Social Sciences and Education

Department of Language and Culture

The phonological status of onsets with multiple articulations in Kalahari Basin Area languages

Andrea Harrison

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Abstract

Languages spoken in the Kalahari Basin Area abound with phonetic complexity, particularly with regard to clicks and stops. In these languages, the root-initial onset position is the only position within a root that allows clicks and most egressive obstruents to occur. Some clicks and obstruents are produced phonetically as sequences of release bursts, such as a coronal stop followed by a dorsal fricative. Thus, these segments involve multiple constrictions of the vocal tract in their articulation. The phonological representation of these segments is controversial. While most older literature interpreted these onsets as unitary segments, it is now more common to interpret these sounds as consonant clusters. A cluster analysis, however, results in a highly unusual syllable typology, where typologically-unmarked Obstruent-Sonorant clusters are absent but marked Obstruent-Obstruent clusters occur. This study examines data from six Kalahari Basin Area languages – Khoekhoegowab, Khwe, !Xóõ, N|uu, Ju|'hoan, and Ekoka !Xun – to assess the phonological status of onsets with multiple release bursts. The data were collected from dictionaries and the phonetic and phonological literature pertaining to these languages. Analysis of the data leads to the conclusion that these onsets are unlikely to be clusters and are rather complex unitary phonemes. The elimination of a cluster analysis requires another phonological interpretation of the onsets to be posited. Previous formal representations of these onsets are found to lack adequate explanatory power, so this thesis proposes a new feature geometry structure to capture the phonological representation of complex onsets in Kalahari Basin Area languages. The proposed model accounts for asymmetries in the click and non-click consonant inventories and posits an expanded set of Lower Vocal Tract features so that phonological patterns can be represented more accurately in these languages.

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List of Abbreviations

BVC	Back Vowel Constraint
C	Consonant
C1	Consonant 1 (in a cluster)
C2	Consonant 2 (in a cluster)
cet	constricted epilaryngeal tube
IPA	International Phonetic Alphabet
KBA	Kalahari Basin Area
LVT	Lower Vocal Tract
MCA	Moderate Cluster Analysis
N	Nasal
O/E	Observed/Expected (Ratio)
OCP	Obligatory Contour Principle
OO	Obstruent-Obstruent
Orth.	Orthography
OS	Obstruent-Sonorant
RCA	Radical Cluster Analysis
RTR	Retracted Tongue Root
SPE	*The Sound Pattern of English*
UVT	Upper Vocal Tract
V	Vowel
VOT	Voice onset time

1 Introduction

The Kalahari Basin Area (KBA) languages – often referred to as 'Khoisan' languages – are a group of languages spoken in southern Africa, within and around South Africa, Botswana, Namibia, and Angola. These languages are known for their use of click sounds in their phonological inventories. They are also known for their highly restricted root and syllable structures, and phonetically complex root onsets. The root-initial onset is of interest as it is the only consonant position allowing clicks in KBA languages. This position may be filled by most obstruents, clicks, or complex/cluster consonant sequences, whereas the root-medial consonant position is extremely restrictive (Vossen, 2013).

The focus of this project is the root-initial onset position and the investigation of dorsal segments or subsegments occurring within this position. Examples of sound sequences occurring in this position are simple clicks, clicks with an egressive dorsal fricative burst after the initial release burst, clicks with an egressive uvular plosive release, and egressive coronal stops with a secondary dorsal fricative release burst. The root onsets are the topic of extensive debate within this field: they are either analysed as clusters or complex unitary phonemes. Roots in KBA languages tend to have a CVCV, CVV, or CVN structure[1] (Vossen, 2013), if root onsets are analysed as single phonemes. If root onsets are analysed as clusters, the structure is then C(C)VC, C(C)V, or C(C)VN. If these onsets are analysed as clusters, they are Obstruent-Obstruent (OO) clusters. No Obstruent-Sonorant (OS) clusters occur in KBA languages, making the onsets highly typologically unusual (Kreitman, 2008). Conversely, analysing these segments as clusters reduces the number of consonants per language inventory which are beyond typical typological ranges.

Ladefoged (1968, p. 1) stated that "the decision as to whether to regard the members of a particular sequence of consonants as single phonemic units, or as clusters is, of course, often arbitrary." This thesis aims to prove Ladefoged's statement wrong. Through the assessment of previous literature and the analysis of onsets in six KBA languages, the phonological status of onsets in these languages as units or clusters will be investigated. The focus of this project is the dorsal segments and accompaniments.

[1] 'C' stands for Consonant, 'V' for Vowel, and 'N' for Nasal consonant.

The following research questions are proposed:

1. Are the onsets that consist phonetically of a click/stop followed by a dorsal release phonological clusters or units?
2. What are the theoretical repercussions of cluster and unit analyses in KBA languages?
3. What phonological patterns or behaviours are the onsets displaying, and what do these patterns expose about the broader phonology of onsets in KBA languages?

Although there has been some research into this topic, not many formal analyses of the sound systems of KBA languages have been made. Those that have been made are often limited in their representations, sometimes only addressing a few aspects of the phonologies of these languages[2]. Furthermore, there is research on various individual languages, but there are not many cross-linguistic studies within this group of languages. This kind of linguistic research is vital, as many KBA languages are moribund or endangered (Nakagawa, Witzlack-Makarevich, et al., 2023). Thus, research in this field is needed to bring more attention to these languages: languages that have a diminishing number of speakers, whose speakers have historically been marginalized or oppressed, and that have been severely underrepresented in broader phonological literature. This project aims to fill some of these gaps by assessing two languages from each language family grouped under the ‘Khoisan’ label, critically evaluating the common consensus of complex onsets as clusters, and contributing to a deeper understanding of the phonological behaviour of dorsal sounds in these languages. The languages investigated in this project are Khoekhoegowab, Khwe, !Xóõ, N|uu, Ju|’hoan, and Ekoka !Xun.

This thesis is organised into seven main chapters. Chapter 2 provides a brief overview of preliminary information that is foundational to works on KBA languages. This includes information about naming conventions, language classification, click phonetics, and notation practices. Chapter 3 is the literature review. Section 3.1 covers theoretical background on the formal representation of sounds through distinctive features and feature geometry, as well as general literature about syllable and onset typologies. Section 3.2 describes previous formal analyses and representations of phonemes in KBA languages. Section 3.3 sets out the arguments for a cluster or unit analysis of root-initial onsets in these languages. Chapter 4 details the materials and methodology used in this study to collect and analyse the data. Chapter 5 is the results section. In this chapter the data are represented, and onset consonant inventories are

[2] This includes work such as Chomsky and Halle (1968), Sagey (1986), and Halle (1995).

formulated for each language. Chapter 6 is the discussion. Section 6.1 and 6.2 analyse the phonological patterns and behaviours of the onsets in question and assess the onsets in each language as clusters or units. Section 6.3 assesses the previous formal analyses and proposes a new feature geometry representation for onsets with a dorsal component. Finally, Chapter 7 concludes the thesis.

2 Conventions and preliminary information about Kalahari Basin Area languages

This section gives a brief overview of terms that are often used in literature about KBA languages, the language families included within a 'Khoisan' grouping and classification thereof, and the notation of sounds in these languages. It also provides a brief description of the phonetic and orthographic representation of click sounds, as well as the general syllable tendencies of KBA languages.

2.1 Naming conventions and language families

The term 'Khoisan' was first used for linguistic classification by Greenberg (1950, 1963) as a label that grouped a variety of non-Bantu click languages. The label itself was coined by anthropologist Leonhard Schultze in 1928, who fabricated it from the Khoekhoe words *khoe,* meaning 'person', and *saa*, an exonym for people who forage for food meaning 'gatherer' (Güldemann, 2014). 'Khoisan' grouped together communities of genetically and ethnically different people and is now a politically sensitive term. It is retained in linguistic classification, even though it is now widely accepted that 'Khoisan' subsumes multiple language families under the umbrella term of a linguistic non-entity.

Greenberg (1963) argued that 'Khoisan' is a language family consisting of three related branches – Northern, Central, and Southern Khoisan – and possibly including two Tanzanian languages, Sandawe and Hadza, but recent investigation has reclassified this group of languages. 'Khoisan' is now usually treated as an umbrella term that includes the Kx'a language family (mostly corresponding to the older label 'Northern Khoisan'), the Khoe-Kwadi language family (formerly known as 'Central Khoisan'), the Tuu family (formerly known as 'Southern Khoisan'), as well as the language isolates Hadza and Sandawe. It is possible that Sandawe is related to Khoe-Kwadi (Güldemann & Elderkin, 2010).

I refer to the languages in this project in two ways, either as KBA languages or as 'Khoisan-group' languages. The former refers to Khoisan-group languages but excludes Sandawe and Hadza (Nakagawa, Witzlack-Makarevich, et al., 2023), and is a more neutral term for this group of languages as it refers to the *sprachbund* where the languages are spoken instead of a linguistic non-entity. The latter emphasises the vacuousness of the term 'Khoisan' while simultaneously retaining conventional nomenclature so that a link to previous literature in this field may be maintained. 'KBA languages' is preferred, but I use 'Khoisan-group languages' where it more accurately represents wording used in previous literature.

This project investigates six KBA languages, with two from each language family. Other languages may be mentioned as they pertain to analyses of the languages in question. Figure 1 below shows every language or lect mentioned in this thesis and the language family within which they are categorised, based on Güldemann (2014) and Fehn et al. (2022). This is not an exhaustive list of KBA languages.

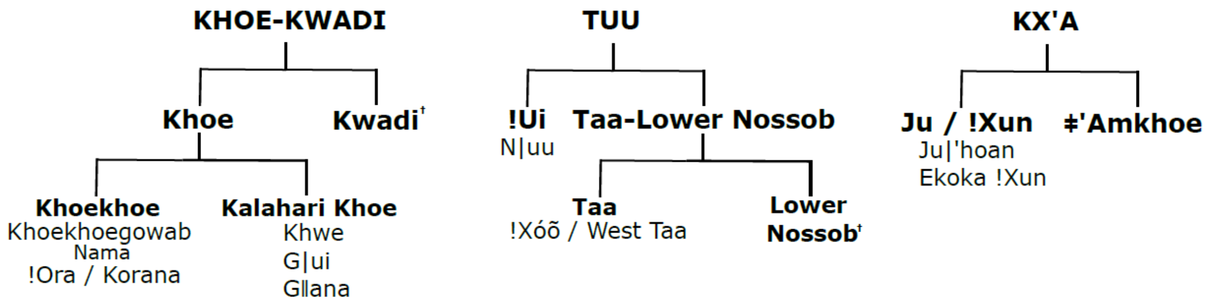

Figure 1. Classification of the Kalahari Basin Area languages/lects mentioned in this thesis. The languages are in plain font, and higher order classificatory labels are in bold. (It should be noted that Nama is part of the language cluster that I refer to as Khoekhoegowab.)

Below is a map from Güldemann (2014) depicting the geographical loci of KBA languages.

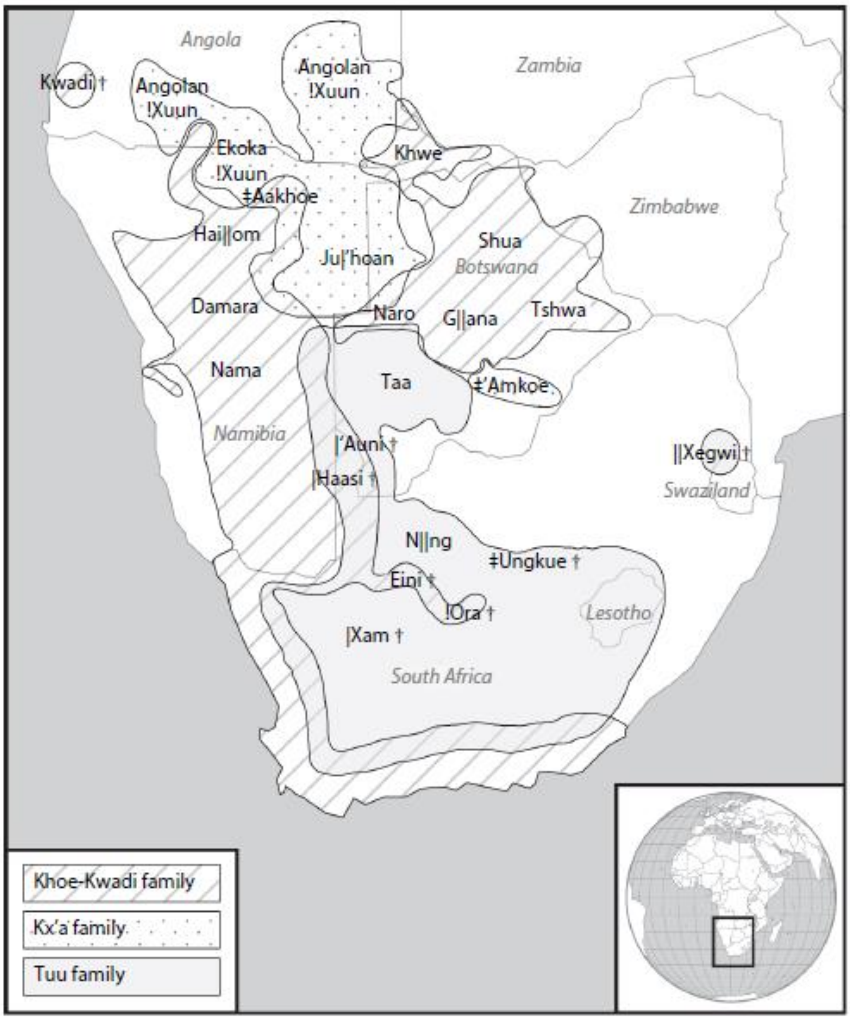

Figure 2. Map from Güldemann (2014), showing languages from the three language families subsumed under the 'Khoisan' label and where they are spoken.

Finally, it should also be noted that the names or spellings of languages may differ across sources. I have tried to adhere to current naming conventions, such as those in Güldemann (2014) that remove Anglicised spellings and suffixes that refer to people rather than languages. However, I have also chosen to retain names that are well-known in the literature – such as '!Xóõ' instead of the more current 'Taa' – as well as some of the names used by the dictionaries that make up my dataset, like 'N|uu' instead of 'N‖ng', and 'Khoekhoegowab' instead of 'Standard Namibian Khoekhoe'. An exception to this is the use of 'Ekoka !Xun' in this paper – it is referred to more generally as 'Northwestern !Xun' in the dictionary (König & Heine, 2008), but I use the name of the specific lect recorded.

2.2 Click sounds

Click sounds are consonants that are produced with suction in the oral cavity. They are articulated by forming two closures – one labial or coronal, and the other dorsal – and then using the tongue to create a vacuum between the two constrictions. When the anterior closure is released, air rushes into the oral cavity and causes the click sound (Sands, 2020). This click burst is the ingressive portion of a click sound – clicks may also have egressive components. Click sounds have often been split into their ingressive and egressive components during phonetic and phonological analysis. The ingressive part was called the 'influx' in older literature and is now usually referred to as the 'click type'. The egressive part was formerly known as the 'efflux' and is now usually referred to as the '(click) accompaniment'.

There are five common click types[3], represented in the International Phonetic Alphabet (IPA) as [ʘ, ǀ, ǁ, !, ǂ]. Click types are named after their anterior place of articulation or the direction of airflow when the anterior closure is released. The acoustic and articulatory characteristics of these click types are briefly described, following Sands (2020). [ʘ] represents the bilabial click, the anterior closure of which is formed by pressing the lips together; its release is fricated. [ǀ] represents the dental click. This click tends to be laminal, its anterior closure made by pressing the blade of the tongue to the upper dental or denti-alveolar area, and it is fricated in its release. [ǁ] represents the (post)alveolar lateral click, usually referred to simply as the 'lateral' or 'alveolar lateral' click. It is a laminal sound and is released with frication. [!] represents the (post)alveolar click. Its anterior closure is apical and varies between languages from alveolar to postalveolar. It has an abrupt release. [ǂ] represents the palatal click. This is an apicolaminal sound with a broad anterior constriction; it is released abruptly[4].

The term 'click accompaniment' groups any additional articulatory gestures in the production of a click sound beyond those used to create the basic click types. "The term 'accompaniments' does not describe a natural class of speech gestures but refers to various laryngeal, nasal, dorsal and other gestures that may occur before, during, or after the release of the anterior click closure" (Sands, 2020, p. 22). Miller et al. (2009) argue that this term is superfluous and that

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[3] Other marginal click types have been observed but are not pertinent to this paper. For an overview of these additional click types, see Bonny Sands's introductory chapter in *Click Consonants*.

[4] It should be noted that Ekoka !Xun uses a fricated palatal click [ʄ] where all related languages use an abrupt palatal click (Sands, 2020).

clicks and their various modifications or types of releases may be analysed within a typical phonological framework using descriptions of place of articulation, manner of articulation, phonation and airstream. The label ‘accompaniment’ is widely used within literature on Khoisan-group languages and so will be maintained in this paper, but it is important to keep in mind that this term does not represent a phonological class of sounds.

It is difficult to represent accompaniments without a click symbol, so in the following section an alveolar click [!] is used to represent any click, with accompaniments being represented around this basic symbol. Possible accompaniments are described below, with their typical representation in previous literature, following their discussion and representation in Sands (2020).

There are various laryngeal gestures that may accompany a basic click. Clicks produced without any accompanying articulatory gestures are referred to as ‘tenuis’ or ‘plain’ clicks. They are usually represented solely by the click type symbol but may also be represented by a voiceless velar stop symbol, e.g. [k!] or [ᵏ!]. Aspiration on clicks may be represented by [!ʰ] or [!h]. Voicing is usually represented by a voiced velar stop symbol before or after the click, e.g. [ᶢ!], [g!], or [!g]. This may also represent prevoicing or ‘voice-lead’ in languages such as Ju|’hoan and !Xóõ. Glottalisation is represented by a glottal plosive symbol following the click, e.g. [!ˀ] or [!ʔ], or with an apostrophe following the click, [!’], although the latter implies that the click is ejected. The production of a glottalised click involves the release of a glottal constriction after the click burst. These clicks often have pulmonic nasal venting throughout the ingressive portion of the click sound, so Sands (2020) suggests the phonetic representation [ᵑ̊!ˀ] or [ᵑ̊!ʔ] for this accompaniment. Voiceless nasal aspiration, also referred to as delayed aspiration or clicks with a delayed glottal fricative, is characterised by a longer voice onset time (VOT) than that of aspirated clicks. Clicks with this accompaniment, unlike aspirated clicks, have nasal venting, so Sands (2020) suggests the representation: [ᵑ̊!ʰ]. In other literature, delayed aspiration has been transcribed variously as *!’h*, *!h*, or *!hɦ*.

There are also nasal click accompaniments. Voiced nasalisation that persists throughout the closure and release of the click is represented by an alveolar nasal plosive symbol before or after the click or velar nasal symbol before the click, e.g. [n!], [!n], or [ᵑ!]. Prenasalisation, which ends before the release of a click, is represented as [ᵑᶢ!] or [ng!]. This accompaniment is rendered as *n!g* in Kilian-Hatz (2003)’s *Khwe Dictionary*. Traill (1985) records a voiceless nasal click for !Xóõ, which he transcribes as *!n̥*.

Dorsal accompaniments include “distinctive constrictions of the back and/or root of the tongue” (Sands, 2020, p. 28). These are the accompaniments that are most controversial in their classification and representation and are also the accompaniments that are of greatest interest in this thesis. Dorsal accompaniments include those previously described as velar or uvular fricatives, affricates, stops, and ejectives. Clicks with dorsal accompaniments may be treated as consonant clusters or complex unitary phonemes, depending on the analysis. These sounds will be discussed in more detail in subsequent sections.

2.3 Notation

The orthographic notation of sounds in Khoisan-group languages is notoriously controversial. First, click phonemes are often produced with much variability in terms of place of articulation, degree of suction, position of the tongue and intensity (Sands, 2020). This poses a challenge for an unambiguous representation and analysis of these sounds. Second, many researchers have used their own idiosyncratic orthography to represent sounds in these languages, so interpreting this data is complicated and often imprecise. Third, theoretical debates around the nature of click phonemes have resulted in varying orthographic systems for the same sets of sounds. For example, authors who believe clicks and their accompaniments to be unitary phonemes tend to use superscripts and diacritics to represent these sounds, whereas authors who believe that clicks and their accompaniments are clusters of segments tend to represent these sounds as a sequence of symbols. Finally, the IPA includes symbols for click types, but does not specify symbols for click accompaniments. This is an obstacle for the creation of a standard representation of click sounds.

To transliterate another author’s orthography into an approximate IPA representation is to risk the misrepresentation and ultimate misinterpretation of sounds in Khoisan-group languages. However, doing so successfully would allow meaningful cross-linguistic comparison. Thus, in this thesis I attempt to retain the orthographies of previous authors when discussing their work unless a symbol is so opaque that it may not reliably be interpreted by a reader familiar with the IPA. I include descriptions of sounds where necessary and I notify the reader of any orthographic changes made.

3 Literature review

The pivotal issue around which this thesis revolves is how to represent KBA language phonemes and interpret their sound sequences. The sounds being investigated are complex consonants or consonant clusters that are restricted to the word-initial onset position. The literature review explores this topic in various ways: through the theoretical framework of features, feature geometry, and cross-linguistic syllable typologies in section 3.1; through previous formal representations of phonemes in Khoisan-group languages in section 3.2; and through specific arguments about the phonological status of onsets with multiple articulations in section 3.3.

3.1 Theoretical background

This section outlines theoretical frameworks for the representation of phonemes – Distinctive Features, Feature Geometry, and the Laryngeal Articulator Model – and then describes relevant theories of syllable structure for analysis of consonants in the onset position.

3.1.1 Feature representation

3.1.1.1 Distinctive Features

The notion of distinctive features rests on the argument that phonemes can be decomposed into bundles of features, and that contrasts in the features of two segments may distinguish the segments from one another (Jakobson et al., 1951). Jakobson et al. (1951) posit a set of binary features meant to capture phonological contrasts in languages. Building on Jakobson et al. (1951)'s suggested features, Chomsky and Halle (1968) proposed an updated set of distinctive features in *The Sound Pattern of English* (*SPE*). Certain features included by Jakobson et al. (1951) but excluded by Chomsky and Halle (1968) were those of 'grave versus acute' and 'compact versus diffuse', which have been used in some descriptions of click sounds. The gravity of a sounds depends on where on a spectrogram the majority of its energy falls. Spectrograms of 'grave' sounds show an energy distribution that is clustered around lower frequencies and those of 'acute' sounds show an energy distribution around higher frequencies. 'Compact' sounds are those which produce spectrograms with one dominant formant or region, as opposed to 'diffuse' sounds which produce spectrograms showing more dispersed energy distribution.

In *SPE*, Chomsky and Halle (1968) categorise their proposed features into four sub-groups: major class features, cavity features, manner of articulation features, and source features. Major class features are used to describe the alternation between opening and closing of the vocal tract. Cavity features include features that account for the position of certain articulators. Manner of articulation features are used to describe varying degrees of closure in the vocal tract. Source features are used to characterise sounds with glottal and laryngeal components and turbulent airflow.

Not all features posited by Chomsky and Halle (1968) are described here, but a few key features relevant to the characterisations of clicks and onsets with dorsal accompaniments are included. Chomsky and Halle's 'Sonorant-Nonsonorant (Obstruent)' feature distinguishes between sounds produced with neutral vocal cords such that spontaneous voicing might occur (sonorants) and those where spontaneous voicing is not possible (obstruents). A 'Voiced-Nonvoiced (Voiceless)' feature distinguishes between 'voiced' sounds, which are produced with vibrating vocal cords, and 'voiceless' sounds, which are produced with a lack of vocal cord vibration due to a widened glottal opening. A 'Coronal-Noncoronal' feature distinguishes between 'coronal' sounds, which are articulated by raising the blade of the tongue from its neutral position, and 'noncoronal' sounds, which have a neutral tongue-blade position. 'Anterior-nonanterior' differentiates between sounds produced with a constriction at or in front of the alveolar region – 'anterior' sounds – and those produced without such a constriction – 'nonanterior' sounds. Furthermore, Chomsky and Halle (1968) posit features related to the position of the tongue body: 'High-Nonhigh', 'Low-Nonlow', and 'Back-Nonback'. These refer to whether the tongue body is, respectively, raised from a neutral position, lowered from a neutral position, or retracted from a neutral position. They note that, due to articulatory constraints, sounds cannot be both [+high] and [+low]. These cavity features rendered Jakobson et al. (1951)'s 'diffuse', 'compact', and 'grave' features redundant. A 'Distributed-Nondistributed' feature classifies sounds into 'distributed' sounds that have a constriction that extends at length along the path of airflow and 'nondistributed' sounds with a shorter constriction in this direction. A 'Nasal-Nonnasal' feature separates sounds produced with a lowered velum and nasal airflow from sounds produced with a raised velum and oral airflow. A 'Lateral-Nonlateral' feature divides the coronal consonants into sounds that are produced with air flowing out of the mouth over the side(s) of the tongue due to a lowering of the middle of the tongue ('lateral'), and the sounds without this direction of airflow (Chomsky & Halle, 1968). The feature 'Continuant-Noncontinant (Stop)' characterises the degree to which the primary constriction is narrowed. Stops are created with a complete occlusion which blocks airflow through the vocal tract, and 'continuants' are produced with a primary constriction that is still sufficiently open for air to flow through. Release features such as 'Instantaneous release-Delayed release' describe the ways in which a closure may be released – the instantaneous release of a closure produces little to no turbulence, whereas the delayed release of a closure produces turbulence. The feature 'Strident-Nonstrident' distinguishes between obstruents with frication and other consonants. 'Strident' sounds are produced with markedly more turbulent airflow than 'nonstrident' sounds (Chomsky & Halle, 1968). 'Stridency' is now commonly understood to apply only to Coronal sounds (Kim et al., 2011). Chomsky and Halle (1968) also posit features referring to 'supplementary movements' of articulators involved in sounds with multiple constrictions. One of these is a 'suction' feature, which is associated with the posterior closure in clicks.

Following the publication of *SPE* (Chomsky & Halle, 1968), Halle and Stevens (1971) proposed a set of laryngeal features that would largely replace the *SPE* 'Source features'. A [+spread glottis] feature refers to a widened glottal opening, causing aspiration. A [+constricted glottis] feature represents the narrowing or full closure of the glottis, causing glottalization or a glottal stop. A [+stiff vocal cords] feature represents increased rate of vocal cord vibration caused by vocal cord stiffening. A [+slack vocal cord] feature refers to the decreased tension of the vocal cords. The positive features mentioned by Halle and Stevens (1971) are all relative to a neutral glottal, laryngeal and vocal cord state.

3.1.1.2 Feature Geometry

While theories of distinctive features explicated the nature of contrastive features, the organisation of these features was not focused upon. Clements (1985) argues that features must be organised hierarchically in 'multi-tiered representations', within which associated sets of features are grouped. This is premised upon conceptualisations of Autosegmental Phonology (Goldsmith, 1976). Thus, individual features are dominated by nodes termed 'class nodes' by Clements. This allows for a more accurate representation of phonological processes, which may affect a group of features. That is, phonological rules could target one feature or a class node. Clements (1985) argues that the class nodes were further dominated by a 'root node', which is also considered a class node and is itself linked to a higher 'CV tier' representing a segment. He postulates five class nodes: the root tier node, the laryngeal tier node, the supralaryngeal tier node, the place tier node, and the manner tier node. The laryngeal tier, immediately dominated by the root node, consists of [spread], [constricted], and [voiced] features. The supralaryngeal node, also immediately dominated by the root node, dominates the manner and place nodes. The manner tier consists of [consonant], [sonorant], [lateral], [nasal], [continuant], and [strident] features. The place tier includes [coronal], [anterior], [distributed], [high], [back], and [rounded] features (Clements, 1985).

Since Clements (1985)'s original proposal, the basic structure of feature geometry has been extensively amended and debated. The Place node is generally accepted to have three dependent nodes: [labial], [coronal], and [dorsal]. The [anterior] and [distributed] features are grouped under the [coronal] node, given that these features only apply to [coronal] sounds (Uffmann, 2011). Sagey (1986) situated [high], [back], and [low] in the daughter positions of the [dorsal] node, and [round] as the daughter of [labial]. Manner features are no longer subsumed under a Manner node, since phonological processes do not tend to target a set of manner features but rather individual manner features (McCarthy, 1988). Additionally, manner features are not articulator bound. McCarthy (1988) argues that the manner features [nasal] and [continuant] are immediately dominated by the Root node and categorises [lateral] as subordinate to [coronal]. He also argues that the major class features [consonant] and [sonorant] – which are not able to spread or delink like other autosegments – are part of the Root node.

Sagey (1986) also proposed that a Root node could have two Place of articulation features, calling these sounds 'complex segments'. She also posited 'contour segments', segments that branched at a terminal node and so had a feature 'contour'. Below is the basic structure of Sagey (1986)'s proposed feature geometry.

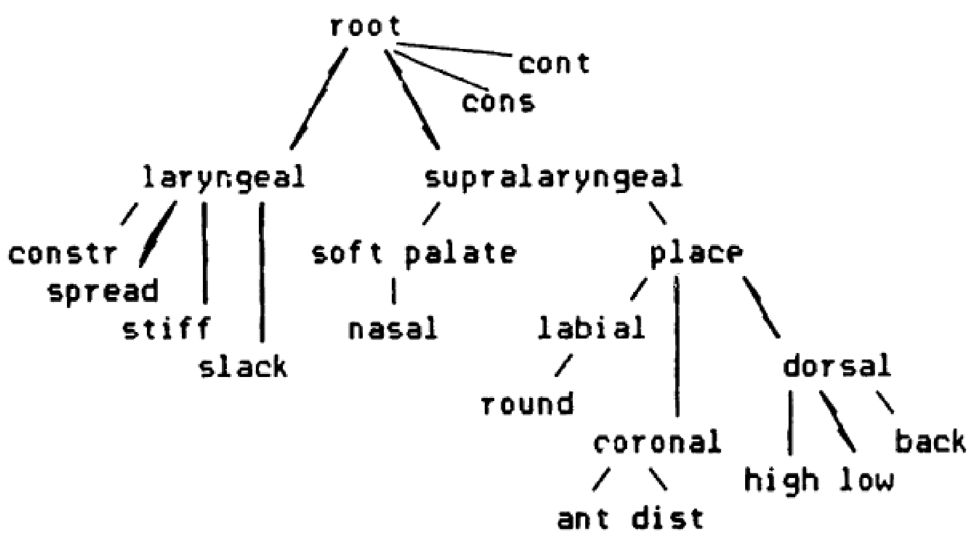

Figure 3. Sagey (1986)'s feature geometry of distinctive features

Clements and Hume (1995) refer to Sagey (1986)'s approach as the 'Articulator-based feature Theory', pointing to the focus of this and similar theories upon independent articulators involved in speech production. Clements and Hume offer an alternative approach that prioritises the role of constrictions of the vocal tract in speech production. This theory allows consonants and vowels to be characterised using the same features: [labial] is used to represent vowel segments that were previously characterised as [+round], [dorsal] replaces the [+back] feature, and [pharyngeal] – an added Place feature – replaces [+low]. In this feature geometry, two sets of identical Place features occur with one set being dominated by a C-Place node – for the representation of consonantal segments – and the other being dominated by a V-Place node – for the representation of vocalic segments. Given that consonants and vowels share the same Place features in this theory, the phonetic interpretation of a Place feature is determined by whether it is dominated by a C-Place node or a V-Place node (Uffmann, 2011). Clements and Hume (1995) argue that the constriction-based model more accurately represents phonological processes occurring where consonants and vowels interact, such as the palatalisation of velar or labial consonants before front vowels. They also argue that this approach allows the straightforward representation secondary articulations, representing secondary articulations of consonants as features beneath the V-node. As the V-Place node is dominated by the C-Place node, the hierarchical nature of the relationship between primary and secondary articulation is naturally encoded in this representation. Reproduced below as Figure 4 is Clements and Hume (1995)'s diagram illustrating their basic feature geometry for consonants and vocoids, with unused nodes – such as the V-Place node in the consonantal representation - excluded.

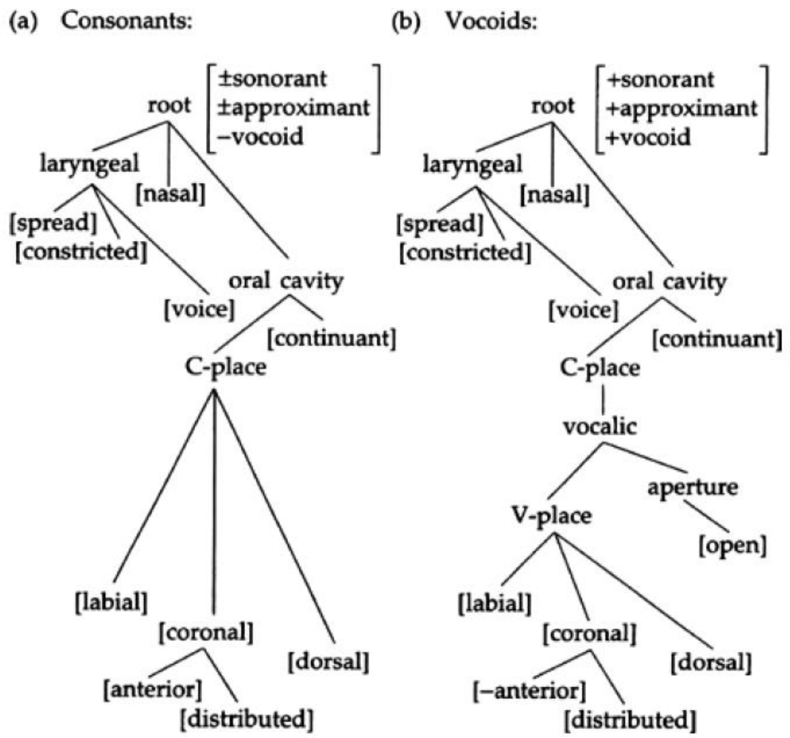

Figure 4. Clements and Hume (1995)'s feature geometry for the representation of a consonantal segment and a vocoid segment

Another set of changes pertaining to uvular, pharyngeal, and glottal sounds has been made since the original feature geometry proposal by Clements (1985). McCarthy (1988) suggests that a fourth Place feature – [pharyngeal] – be added alongside Labial, Coronal, and Dorsal. This feature characterised uvular fricatives (but not plosives), and pharyngeal and glottal obstruents. These sounds were grouped in this way by McCarthy as he argues that the 'pharyngeal sounds' function as a phonological class in Semitic languages. Conversely, Trigo (1991) proposes two pharyngeal features: an 'advanced tongue root' feature and a 'lowered larynx' feature. These are independent of the other laryngeal features as well as the Place features, and are characterised by Trigo as 'secondary place features'. Subsequently, Halle (1995) posits a 'Guttural' node that dominates a 'Laryngeal' node and a 'Tongue Root' node, and characterises uvular, pharyngeal, and glottal obstruents. In this analysis, a 'retracted tongue root' (RTR) feature distinguishes uvulars and pharyngeals – [+RTR] – from laryngeals – [-RTR]. Uvulars and pharyngeals are distinguished by uvulars having secondary Dorsal [+back, -high] features. Drawing on Halle (1995) and McCarthy (1988), Rose (1996) suggests that the Place features are divided into two branches: 'Oral' and 'Pharyngeal'. All uvulars, pharyngeals, and laryngeals have a 'Pharyngeal' Place feature. Rose also argues that [RTR] defines all non-laryngeal gutturals. In Rose's analysis, uvular plosives are both Oral and Pharyngeal, while uvular fricatives are only Pharyngeal – this division is based on evidence from Semitic languages that uvular stops tend to pattern with velars and not uvular fricatives. Rose (1996) further identifies two types of phonological effect caused by Pharyngeal segments and affecting vowel change. She argues that [RTR]-spreading yields a retracted vowel allophone, and Pharyngeal node-spreading results in the lowering of a vowel to [a]. These proposals led to an Articulator-Based feature geometry structure proposed by Vaux (1999), depicted in Figure 5. Vaux replaces the traditional Place node with Upper Vocal Tract (UVT) and the Laryngeal or Guttural node with Lower Vocal Tract (LVT). The LVT node allows for more specification of the consonants produced around and beyond the uvula.

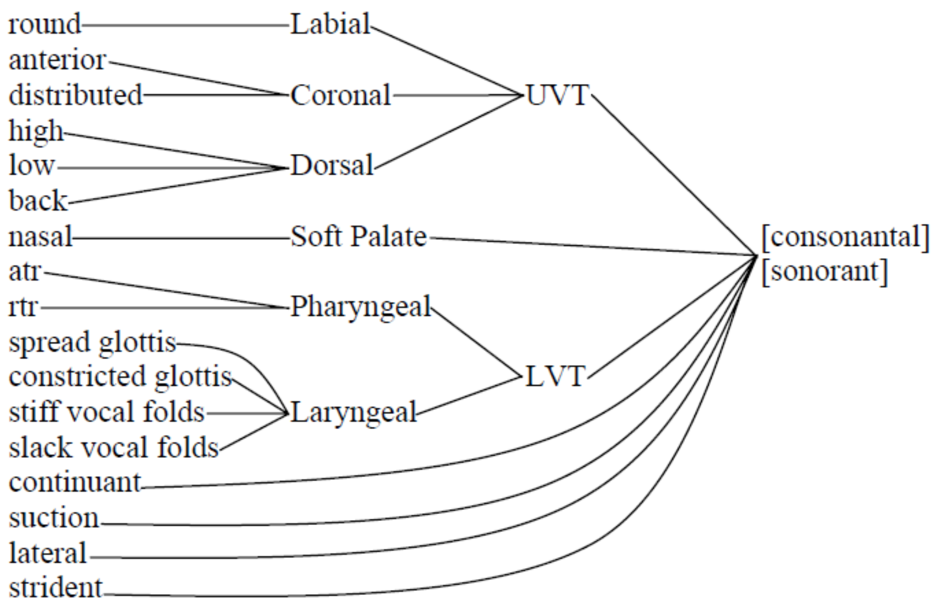

Figure 5. Vaux (1999)'s Articulator-Based feature geometry, with UVT standing for Upper Vocal Tract and LVT standing for Lower Vocal Tract.

As is evident from these proposals, the characterisation of post-velar segments is controversial, and feature geometries that attempt to capture these segments vary widely in their formulation.

3.1.1.3 The Laryngeal Articulator Model

Given the varying structures proposed to represent guttural phonemes and lack of attention that these sounds received in many other formal representations, Esling (2005) proposed the 'Laryngeal Articulator Model'. This model's primary function was to critique the standard vowel chart for not accounting for laryngeal activity in vowel production. Esling argues that a 'High-Low-Front-Back' system of representing vowel quality was inadequate. Importantly, he argues that 'back-ness' of the tongue is an impoverished phonological concept as it is neither physiologically accurate – as it cannot fully represent the complexity of tongue movement in the posterior part of the vocal tract – and nor is it "phonetically sufficient to carry all of the auditory labels that are now known to be associated with changes in oral and laryngeal vocal tract quality" (Esling, 2005, p. 14). He posits a move away from vowel articulations as happening only in the oral tract and proposes a model that splits the vocal tract into a laryngeal cavity and an oral cavity. The oral cavity is responsible for two tongue movement directions – fronting and raising. The laryngeal cavity is responsible for the retraction of the tongue[5]. In Esling's model, the aryepiglottic folds are an active articulator that is responsible for the closing of the glottal passage, laryngeal raising and tongue retraction, all of which contribute to changing the shape and volume of the pharynx. He calls the aryepiglottic folds the 'laryngeal constrictor mechanism'. The following diagram from Esling (2005), reproduced as Figure 6, shows the vocal tract split into an Oral Tract and a Laryngeal Tract.

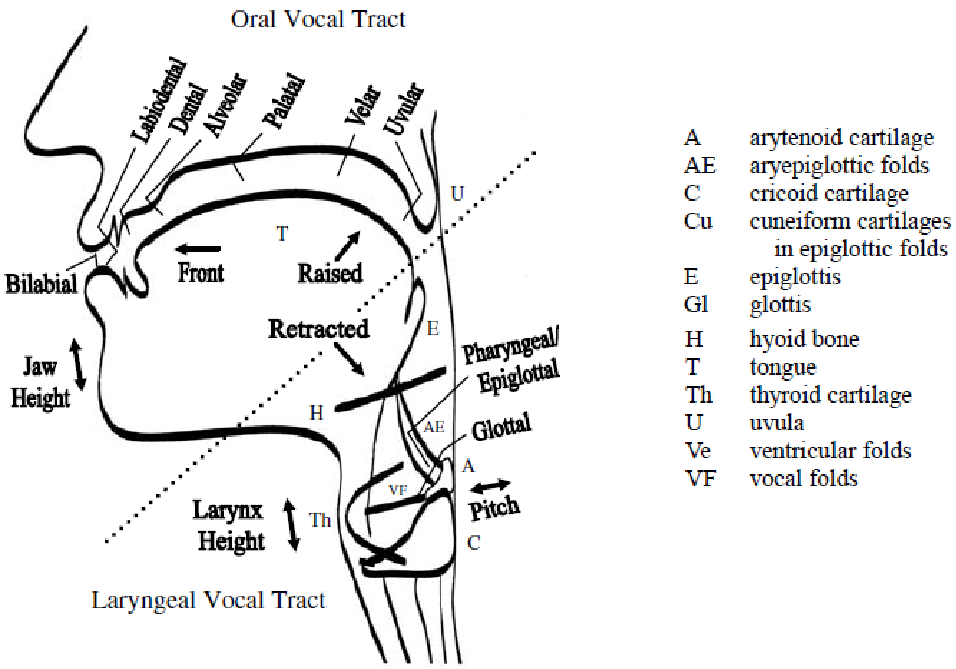

Figure 6. Esling (2005)'s diagram of the vocal tract, split into the Oral and Laryngeal Tracts

In his diagram, uvular sounds are still part of the oral tract, whereas any post-uvular sounds are articulated in and by the laryngeal tract. In the production of pharyngeal sounds, the arytenoid cartilages move upwards and forward. These sounds also involve retraction of the tongue root and laryngeal raising, caused by the constriction of the aryepiglottic folds. Esling also argues that the laryngeal constrictor controls tongue retraction. That is, "pharyngeals are not a function

[5] In a later work, Esling et al. (2019) have 'retraction' crossing the dividing line between the Oral and Laryngeal Tracts, thus representing it in both tracts.

of independent movement of the tongue in the same way that uvulars, velars, or dentals are" (Esling, 2005, p. 26).

Following Esling (2005), Moisik et al. (2012) posit an 'Epilaryngeal Articulator' to account for post-velar consonantal sounds. Moisik et al. (2012) identify the epilaryngeal tube as the portion of the larynx that extends from just above the vocal folds until the epiglottis. They emphasise the separation of the epilaryngeal tube from the glottis, stating that epilaryngeal constriction is independent of vocal fold activity. They argue that phonological models positing tongue root retraction to account for epilaryngeal constriction are inadequate. They discuss models such as the one posited by Rose (1996). Moisik et al. (2012) argue that, in Rose's model, pharyngeal sounds are inherently associated with retraction of the tongue root which groups pharyngeals and uvulars together, thus predicting that these sounds will have the same phonological effects. This is incorrect, as evidence from Arabic shows that uvular sounds trigger retraction on following vowels, but pharyngeals do not. In other models such as Halle (1995), where a Guttural node is posited to dominate Laryngeal and Tongue Root nodes, Moisik et al. (2012) argue that this configuration does not fully capture the relationship between lingual and laryngeal features, such as the influence of [RTR] on the status of laryngeal features.

Thus, Moisik et al. (2012) propose a new articulator category which has the same phonological status as other Place categories. The call this category [epilaryngeal], and posit an additional feature called [constricted epilaryngeal tube (cet)]. The function of the [cet] feature overlaps with those of previously suggested features [RTR] and [constricted glottis]. [cet] is not a lingual feature, and thus cannot determine tongue movement phonologically, so a [retracted] feature is suggested to account for general tongue retraction (as opposed to tongue root retraction). Thus, the [cet] feature is active for glottal/glottalised segments and for retracted/non-retracted pharyngeal segments, and the [retracted] feature is active in retracted pharyngeal segments, uvulars, low back vowels, and retracted vowels. This is premised upon observations that tongue retraction alone may cause pharyngeal constriction but is not sufficient for full epilaryngeal stricture, although it does play a facilitatory role in the latter. Moisik et al. (2012)'s proposal does not bind pharyngeals to [RTR] and therefore vowel retraction. Thus, epilaryngeal stricture is not defined by [RTR] and is instead defined by the adduction of the epilaryngeal tube and the constriction of the epilaryngeal space by laryngeal raising.

Moisik et al. (2012) posit the following feature geometry for their ‘Phonological version of the Laryngeal Articulator Model’ (Figure 7).

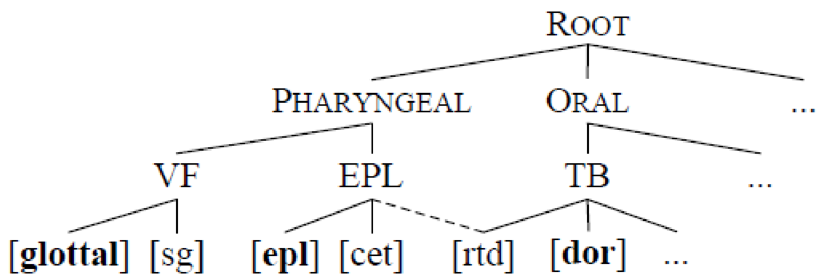

Figure 7. Moisik et al. (2012)'s phonological model with a laryngeal articulator. ‘VF’ stands for Vocal Folds, ‘EPL’ for Epilaryngeal Tube, ‘TB’ for Tongue Body, [sg] for spread glottis, [epl] for epilaryngeal, [cet] for constricted epilaryngeal tube, [rtd] for retracted, and [dor] for dorsal.

Moisik et al. (2012) position the [retracted] feature as dually-linked with the Epilaryngeal Tube and Tongue Body nodes, arguing that dual-linking is often permitted in feature geometry. The [retracted] feature is the daughter node of Tongue Body but may be associated with Epilaryngeal Tube. Moreover, they state that a pharyngeal that has a [retracted] feature will tend to cause vowel retraction, but pharyngeals not specified for [retracted] will not. Pharyngeals are phonologically identified by [cet], which distinguished them from uvulars, which are characterised by [retracted]. Thus, the model predicts different effects on vowels by pharyngeals and uvulars. It also predicts that a phonological process resulting in the loss of the Oral node leaves Epilaryngeal features intact and allows [retracted] to remain as a dependent node of Epilaryngeal Tube. Furthermore, Moisik et al. (2012) characterise the uvular plosive [q] as being [retracted] only at the Tongue Body node, but characterise the uvular fricative [χ] as having dual-linking of [retracted] and so also being specified as Epilaryngeal.

3.1.2 Syllable typologies and onsets

3.1.2.1 Syllables and sonority

The syllabic position of concern in this thesis is the onset position. Various principles and theories have been proposed to explain cross-linguistic trends in syllable typology, and those relevant to this analysis will be described below.

Cross-linguistically, the least marked syllable shape is that of CV – ‘C’ being a consonantal segment and ‘V’ being a vowel or syllabic consonant. Syllable typology generally reflects certain universal tendencies. For instance, syllable onsets tend to be preferred and codas tend to be dispreferred. There is no language that requires codas, and no language that bans onsets (Zec, 2007). A language may, however, ban complex onsets.

Syllable positions are often analysed through the lens of sonority. Selkirk (1984, p. 116) posited the ‘Sonority Sequencing Generalisation’, which stated that “[i]n any syllable, there is a segment constituting a sonority peak that is preceded and/or followed by a sequence of segments with progressively decreasing sonority values.” That is, the most sonorant segment forms the nucleus of the syllable, and the margins – the onset and coda – are less sonorous. In the case of complex onsets or codas, this means that the consonant positions at the furthest edges of the syllable are occupied by the least sonorous segments and inner consonant positions are occupied by segments that are more sonorous than those in the margins but less sonorous than the syllable nucleus. This theory required a sonority hierarchy within which segments are categorised so that the sonority of segments within a syllable could be assessed. Vennemann (1988) had suggested a ‘consonantal strength hierarchy’, which ranked segments in decreasing order of consonantal strength as follows: voiceless plosives, voiced plosives, voiceless fricatives, voiced fricatives, nasals, lateral liquids, central liquids, high vowels, mid vowels, and low vowels. Selkirk (1984) inverted this scale to create a sonority hierarchy. Thus, obstruents are the least sonorous and vowels the most sonorous.

Selkirk (1984) points out that sonority is relational – that is, segments in a syllable are measured as more or less sonorous in relation to one another. This allows for constraints to be proposed that restrict the ‘sonority distance’ between two segments within a syllable. This is pertinent for the analysis of consonant clusters in the syllable-initial position. Steriade (1982) suggests that languages have a restriction on ‘Minimal Sonority Distance’ – thus, there are language-specific restrictions as to how similar adjacent segments in an onset may be in terms of sonority ranking. In a less granular sonority scale than that mentioned above, such as Vowel (1) > Glide (2) > Liquid (3) > Nasal (4) > Obstruent (5), a language may restrict its onset clusters to a Minimal Sonority Distance of – for example – two, thus allowing Obstruent-Liquid and Nasal-Glide clusters, as well as Obstruent-Glide clusters. Conversely, Clements (1990) proposes the ‘Sonority Dispersion Principle’, which states that segments forming a CCV sequence should be evenly separated from one another in terms of sonority, thus making Obstruent-Liquid clusters the ideal cluster type.

3.1.2.2 Onset clusters

This section briefly describes research on onset clusters regarding their typology and phonological analysis.

Bennett (2020) states that there are three types of clusters that are ‘privileged’ cross-linguistically. These are clusters of a coronal sibilant plus another consonant, clusters of a consonant plus a sonorant, and clusters of a nasal plus a following consonant (Bennett, 2020).

Kreitman (2008) investigated the typology of bi-consonantal onset clusters, surveying 62 languages across 22 language families. She found that, without exception, no languages permitted only OO clusters. Any languages that permitted such clusters also permitted OS clusters. Furthermore, a study by Morelli (1999) found that languages with OO clusters tend to allow stop-stop and stop-fricative clusters only if fricative-stop clusters are also allowed.

Gouskova and Stanton (2021) investigate sound sequences that may be analysed as affricates or consonant clusters. They suggest three approaches for ‘diagnosing’ clusters. The first is to investigate the inventory structure: consider a language with a three-way laryngeal contrast in stops – voiceless, ejective, aspirated. Fricatives in this language do not have laryngeal contrasts. Thus, if a sequence such as [ts^h] occurs, this sequence must be a unitary phoneme as it cannot be a combination of /t/ and /s^h/, given that /s^h/ does not exist in the inventory of the language. The second approach is to examine the syllable phonotactics of a language: if a language has no clusters except for a [ts] sequence, analysing [ts] as a cluster means that it would be the only consonant cluster onset allowed, which would be highly irregular. The third approach is to investigate other distributional patterns: if a language has a particular distributional restriction that applies to – for example – stops but not fricatives, and this restriction also applies to a sound like [ts], [ts] is patterning with stop phonemes and is not a cluster made up of /t/ and /s/ (Gouskova & Stanton, 2021).

Riehl (2008) proposes a three-step process for determining the phonological status of a Nasal-Obstruent sound sequence. This process may be extended more generally to consonantal sound sequences of dubious phonological status. The first step is to assess the divisibility of the sound sequence. If the two components in a sound sequence do not occur independently in the consonant inventory of that language, the sequence is indivisible and must be analysed as a unitary phoneme. If the sounds are separable, Riehl then assesses the syllable positions occupied by the sound sequence. If the sound sequence only occurs in heterosyllabic environments, in a language that permits codas elsewhere, it is a cluster. If it occurs tautosyllabically, more evidence is needed to determine phonological status. If there is more evidence for a unit analysis of this sound sequence, such as the language lacking other consonant clusters or the sound sequence violating the Sonority Sequencing Principle, then it is a unitary phoneme. If there is no other evidence for a unitary analysis, the sound sequence is a cluster (Riehl, 2008).

3.2 Formal representations of phonemes in Khoisan-group languages

Only a few phonological analyses have been applied to the languages that have been subsumed under the Khoisan-group label. The following section outlines works that have undertaken phonological analyses of these languages.

3.2.1 Chomsky and Halle (1968)

In *SPE*, Chomsky and Halle (1968, p. 319) describe clicks as having multiple simultaneous closures, calling them "noncontinuants with extreme velarization, i.e., $\begin{bmatrix}\text{+high}\\ \text{+back}\end{bmatrix}$". Chomsky and Halle (1968) state that rarefaction of the oral cavity is needed to produce a click, created by "a downward movement of [the velar closure]". To capture this, they create a [suction] feature. They further note that glottalisation of clicks may occur.

Chomsky and Halle premise their analysis of clicks upon descriptions of Nama clicks by Beach (1938), who splits the articulation of click sounds into an 'influx' and 'efflux'. Chomsky and Halle (1968, p. 319) note that the term 'influx' "subsumes the features that are relevant for the primary constriction" and that "all other click features" fall under the label of 'efflux'. As Chomsky and Halle make regular reference to Beach's phonetic descriptions, Beach (1938)'s table of click sounds in Nama is reproduced below as Table 1. A key is included below the table, extrapolated from Beach's descriptions, so that his symbols may be connected to more current descriptions in Khoisan-group literature.

Table 1. Beach (1938)'s table of Nama clicks

Efflux → / Influx ↓	1. Weak velar plosive	2. Strong velar affricative	3. Glottal plosive	4. Glottal fricative	5. Voiced nasal
1. Dental affricative	ʇ	ʇx	ʇʔ	ʇh	[illegible]
2. Denti-alveolar implosive	§	§x	§ʔ	§h	[illegible]
3. Lateral affricative	ʖ	ʖx	ʖʔ	ʖh	[illegible]
4. Alveolar implosive	ʗ	ʗx	ʗʔ	ʗh	[illegible]

'Influxes': 1. Dental click [ǀ], 2. Palatal click [ǂ], 3. Alveolar lateral click [ǁ], 4. (Post)alveolar click [!]
'Effluxes': 1. Simple click (no accompaniment), 2. Click with dorsal affricate release, 3. Click with glottal plosive release, 4. Click with delayed glottal fricative release, 5. Nasal click

Chomsky and Halle (1968) used Beach's descriptions to propose features for each click type. Chomksy and Halle differentiate between click types using the distinctive features [anterior], [coronal], [delayed primary release], and [lateral]. All Nama clicks are classified as Coronal, with the dental and palatal clicks being [+anterior] and the alveolar lateral and (post)alveolar clicks being [-anterior]. The [delayed primary release] feature is used to distinguish between Beach's 'affricative' and 'implosive' clicks, with the dental and lateral clicks being [+delayed primary release] and the palatal and (post)alveolar clicks being [-delayed primary release].

Chomsky and Halle (1968) then propose a featural account of the afore-mentioned click accompaniments, as well as one other accompaniment – described by Beach (1938) as a 'velar glottalic affricative efflux' – not found in Nama but it the related language 'Korana'[6]. They propose a [+nasal] feature for Beach's 'voiced nasal efflux', and a [-nasal] feature for other accompaniments. The non-nasal accompaniments are accounted for by positing three phonologically active places of closure. Chomsky and Halle identify three closures: primary (anterior), secondary (posterior) and tertiary (glottal) closures. The primary and secondary closures may be released immediately or with a delay, but the tertiary closure is restricted to an immediate release only. The delayed release of the primary closure results in an 'affricated'

[6] 'Korana' is an older, now-outdated name for the !Ora language.

anterior burst and a delayed release of the secondary closure results in an affricated or fricated velar/post-velar burst. An immediate release of the secondary closure results in an inaudible posterior burst, corresponding to Beach's first type of efflux. A release of the tertiary closure at the glottis results in a glottalized click. Clicks with a glottal fricative accompaniment are described by Chomsky and Halle (1968) as having 'heightened subglottal pressure'. A 'movement of glottal closure' feature applying to glottalised segments separates glottal stop accompaniment from the ejective accompaniment. They suggest the following feature matrix for the Korana 'effluxes', and I include a key below linking their symbols to Beach's effluxes.

Table 2. Chomsky and Halle (1968)'s feature matrix for Korana accompaniments

	N	*k*	*kxh*	*ʔ*	*h*	*kxʔ*
nasal	+	–	–	–	–	–
delayed release of secondary closure	–	–	+	–	–	+
glottal (tertiary) closure	–	–	–	+	–	+
heightened subglottal pressure	–	–	+	–	+	–
movement of glottal closure	n	n	n	–	n	+

n = not applicable

N = "nasal", k = "weak velar plosive", kxh = "strong velar affricative", ʔ = "glottal plosive",
h = "glottal fricative", kxʔ = "velar glottalic affricative"

Finally, Chomsky and Halle (1968) provide an acoustic explanation for the order of releases of the multiple closures. Releases of closures may be simultaneous or staggered. In the cases of non-simultaneous releases, Chomsky and Halle argue that the primary closure is released before the secondary closure, which itself is released before the tertiary closure. That is, the closures are released "in order of increasing distance from the lips" (Chomsky & Halle, 1968, p. 324), as the vocal tract needs to be open for the acoustic effects of the secondary and tertiary releases to be perceived. Thus, the ordering of closure releases may be a phonetic phenomenon instead of a phonological one.

3.2.2 Traill (1985)

Traill (1985) describes the phonetic details of the !Xóõ sound system and provides a phonological analysis for the language. The sections of this work that are pertinent to this thesis are Traill's phonological argument based on the distribution of consonants, his explanation of a phonological restriction called the Back Vowel Constraint (BVC) and an assimilatory effect now referred to as /a/-raising, his critique of the feature set suggested by Chomsky and Halle

(1968), and his own suggested feature set for !Xóõ consonants, all of which will be described in the following subsections.

3.2.2.1 The distribution of !Xóõ clicks

Traill (1985, p. 166) observes that clicks are only allowed stem-initially in !Xóõ and, moreover, that the vast majority of stem-initial consonants are clicks: "72,5% of initials are clicks, 22,5% are stops, 3% are fricatives and 2% are nasals." Based on this, Traill hypothesizes that !Xóõ phonology is the 'maximisation' of the tendency for 'strong' consonants to appear in the syllable-initial position. He premises his argument on Hooper (1976)'s consonantal strength hierarchy and syllable preferences, by which the optimal syllable is considered to have a 'strong' consonant in the initial position (Hooper, 1976). Traill (1985) states that !Xóõ syllables fit this principle well, with 'strong' consonants in the stem-initial position[7].

Traill (1985) notes that clicks have not been assessed within a strength hierarchy and argues that clicks are the 'strongest' class of sounds in !Xóõ. He quotes Hooper (1976)'s definition of the Optimal Syllable Principle, adding his own emphasis (preserved here):

> The higher the strength scale value permitted in a given C position, the greater the likelihood that a C will occur in the position, *and the higher the strength value for the C*. Similarly, the lower the strength value permitted in a C position, the less likely that a C will occur in that position. (Traill, 1985, p. 168)

As clicks are the segments most likely to appear in the stem-initial position in !Xóõ, preferable even to egressive stops, Traill suggests that clicks are the 'strongest' type of segment in !Xóõ.

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[7] It should be noted that Traill (1985)'s 'initial' position is not the same as Hooper (1976)'s 'initial' position: Hooper refers to the initial position in a syllable, whereas Traill refers to the initial position in a stem. Traill argues that the application of Hooper's principle is still applicable in !Xóõ, with the caveat that the syllable-initial position is weakened in an intervocalic context. Thus, Traill argues, the intrinsic phonological strength of the syllable-initial position is only apparent when the syllable- and word-boundaries overlap.

Using the distribution of consonants and phonological patterns observed in !Xóõ, Traill suggests an expanded language-specific consonantal strength scale:

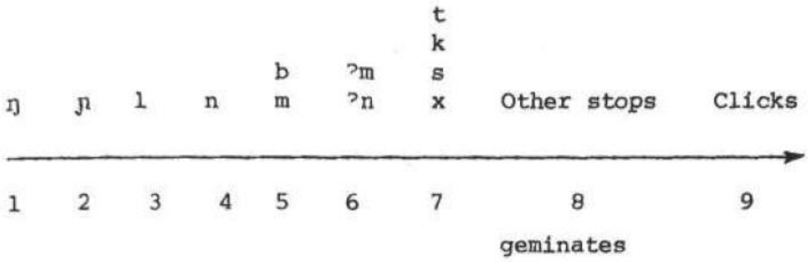

Figure 8. Traill (1985)'s consonantal strength hierarchy for !Xóõ.

This work is pertinent to any sort of sonority or syllable-structure analysis for Khoisan-group languages.

3.2.2.2 Phonological constraints on vowel distribution

The BVC is a phonotactic constraint on vowel qualities following a [+back] consonant. It states that the vowel following a consonant that is [+back] must also be [+back] – that is, [a, o, u] (Traill, 1985). Traill defines [+back] in !Xóõ as having positive Back Height values and/or showing pharyngeal narrowing. Exceptions include a grammatical particle that has the forms [ki] and [ke]. Traill argues that [k] is not always subject to the BVC as it is the only [+back] consonant without the reinforcement of pharyngeal narrowing. Other exceptions include a group of words beginning with [|] or [ǂ] followed by a long front vowel. Traill argues that these front vowels derive from an assimilatory process that raises underlying /a/ vowels to an [i] before the singular suffix /-i/. Traill notes that the BVC applies – with variation – across "all Khoisan languages, with very few exceptions" (Traill, 1985, p. 91).

Similar to the assimilation exception is the raising of /a/ in various sound environments. Traill notes that this vowel raises under assimilatory pressure from a preceding dental consonant – such as /t, |, ǂ/ – or a successive [i] or [n], the latter condition occuring directly after /a/ or separated from /a/ by an intervening medial consonant.

These phenomena have been used widely in later literature as evidence for a phonological velar closure in clicks and a coronal feature in dental and palatal clicks.

3.2.2.3 A feature analysis of !Xóõ clicks

Traill (1985) is critical of Chomsky and Halle (1968)'s suggested click features. He argues against their classification of clicks as 'velarised consonants' specified for [+high, +back], and finds their use of [coronal] and [anterior] features lacking in explanatory power for !Xóõ phonetics and phonology.

Chomsky and Halle use [-high, -low, +back] for uvulars. Traill argues that !Xóõ uvulars should be characterised as [+high], as the body of the tongue is raised in the production of these sounds. Traill further argues that Chomsky and Halle's system cannot capture the phonological contrast between a basic click such as [!], and a click with a uvular stop accompaniment such as [!q]. Both sounds would be – under Chomsky and Halle's analysis – [+high, +back] because they are clicks, but [!q] would additionally be specified for [-high, +back] because of its uvular component. This results in the segment [!q] having both a [+high] and [-high] feature. Traill suggests that this is an inherent flaw of the unit analysis, and that it could be solved by analysing clicks such as [!q] as clusters.

Moreover, Traill (1985) disagrees with the proposal and application of Chomsky and Halle (1968)'s release features. He argues that a delayed secondary release feature is not universally applicable, and its appropriateness for only Khoisan-group languages complicates the machinery of phonetic theory. He also argues that his cineradiology data show that the articulatory position changes between the production of a click and *x* accompaniment. Thus, "the accompaniment is strictly *not* [sic] the result of delaying the release of the velar closure of the click" as the fricative accompaniment is uvular, requiring articulatory movement between the two components of the segment (Traill, 1985, p. 198). He further states that most accompaniments occurring in !Xóõ also occur as 'phonetically identical' independent phonemes, and that the *SPE* analysis cannot capture this aspect of !Xóõ phonology, as the *SPE* featural representation of phonemic [x] versus accompaniment *x* will always differ. Traill argues that these and other phonetic details are not predictable from the features proposed by Chomsky and Halle (1968). Traill (1985) also argues that the delayed secondary release feature cannot be used for sequences such as [tx] and [tsx] as this feature only applies to articulations with a complete closure, and these segments do not have a complete secondary closure. Thus, the fricative component in [tx] cannot be represented identically to the fricative component in [ǂx], despite these fricatives having significant phonetic and phonological similarities.

Traill (1985) then proposes his own set of features for !Xóõ within a unit analysis, despite arguing that a cluster analysis would yield a more accurate phonological representation of sounds in !Xóõ. He proposes the following Place of Articulation features for !Xóõ: [labial], [dental], [velar] and [uvular]. The [velar] and [uvular] features are both associated with a [+high] tongue position. Traill further proposes the following features for representing click accompaniments: [friction], [glottal], [ejected], [voice], [aspirated] and [nasal], with the feature [uvular] also being used for accompaniments. He argues that these features may be applied to the non-click consonant inventory too, with clicks and non-click consonants differentiated by a [suction] feature. Traill (1985) identifies some issues with his own analysis. He notes certain redundancies; for instance, [+back] is specified in velar and uvular segments even though it is implicit in the [velar] and [uvular] feature, and the [friction] feature must be specified twice for segments with an anterior and posterior release. The latter poses a problem for Traill, as he argues that phonological specification "cannot consist of an unordered set of features" (Traill, 1985, p. 207). Thus, "real time" needs to be incorporated into phoneme specification, which mixes phonetics into phonology. Traill also argues that segments such as [tx] and [tsx] are only distinguishable from clicks through the [suction] feature and that this feature set over-predicts similar [-suction] segments. Traill (1985) concludes that these problems would be solved through a cluster analysis.

3.2.3 Sagey (1986)

In her dissertation, Sagey (1986) analyses clicks in !Xóõ, !Xun, Nama and Korana. She characterises clicks as complex segments: segments with "unordered or simultaneous multiple articulations" within the place node (Sagey, 1986, p. 2). She refers to clicks as 'coronovelars' – that is, segments that have both a coronal and velar place of articulation . Also pertinent to this paper is Sagey's description of a contour segment, which is a single segment that is made up of a phonologically-ordered sequence of changing features. She characterises affricates as contour segments as there is a contour from [-continuant] to [+continuant] over the course of the segment. Sagey's thesis is vital to a phonological analysis of Khoisan-group languages. Her various arguments addressing aspects of Khoisan-group phonologies are laid out in the subsections below.

3.2.3.1 Coronal and dorsal articulations are phonologically unordered in !Xóõ clicks

Sagey (1986) argues that !Xóõ clicks have phonologically unordered coronal and dorsal articulations, as 'dental' clicks – that is, the dental click [|] and the palatal click [ǂ] – behave phonologically as both coronal and dorsal segments. Crucial to her analysis is the suggestion that clicks have two Places of Articulation. Sagey provides the following figures to illustrate her featural analysis for these clicks.

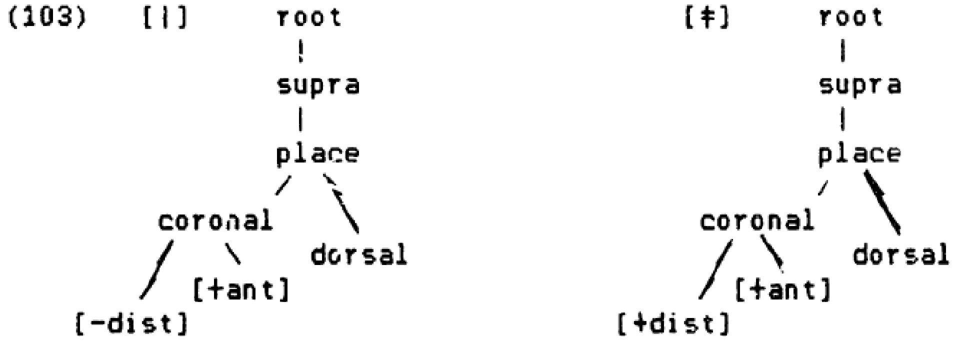

Figure 9. Sagey (1986)'s feature diagrams illustrating the two Place of Articulation features for each click.

Sagey (1986) argues that the dental and palatal click behave both as coronal and dorsal segments based on /a/-raising and the BVC. Regarding /a/-raising, Sagey argues that dental and palatal clicks behave as dental consonants with respect to right edge effects. These clicks create a phonological environment where dental assimilation takes place, meaning that these segments must be Coronal at their right edge. Sagey also argues that the BVC supports the notion of unordered articulator node features, given that this constraint requires a vowel following a Dorsal consonant to be [+back] and that it applies to clicks. Thus, clicks behave phonologically as if they are Dorsal consonants at their right edge. Because of this, the clicks need to have unordered Coronal and Dorsal articulator nodes (Sagey, 1986). Where both processes occur, such as after a palatal click, a vowel may surface as [i] but is underlyingly /a/ (Sagey, 1986; Traill, 1985). This, Sagey posits, is proof that clicks are both phonologically Coronal and Dorsal, and that these articulator nodes are unordered as both Places of Articulation affect phonologically processes at the right edge of the segment.

3.2.3.2 Clicks in Nama and Korana

Sagey (1986) draws on previous analyses of clicks in Nama and Korana by Chomsky and Halle (1968) and Beach (1938). She posits that all clicks in Nama and Korana are both coronal and velar within unitary phonemes: "digraphs and trigraphs represent single, unitary segments, not sequences", analysing nasal and glottal features as "features of the click as a whole" (Sagey, 1986, p. 156).

Sagey suggests a possible set of distinctive features for clicks in these languages, premised upon distinctive affrication. That is, the Coronal and Dorsal articulations of a click may independently be specified for [continuant], yielding different continuant features for each place of articulation. Her diagram below illustrates this proposal for four clicks: [ǀ], [ǀx], [ǂ], [ǂx].

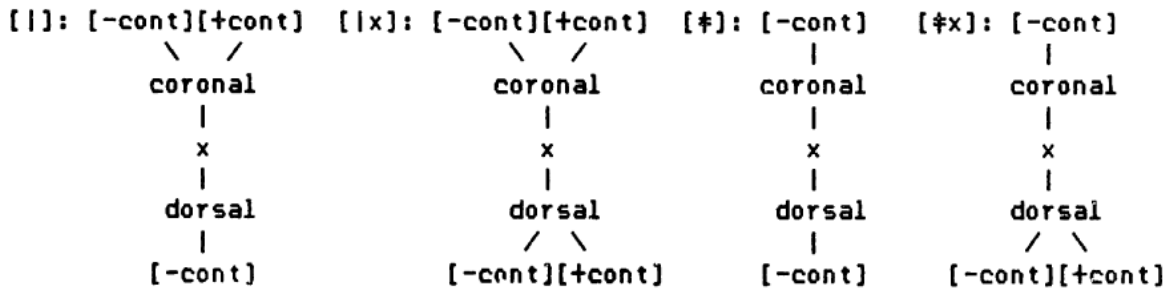

Figure 10. Sagey (1986)'s proposed features distinguishing clicks by articulator-specific [continuant] features.

However, Sagey states that affrication may not be distinctive, instead being predictable from other features. If this is so, the argument for separate degrees of closure collapses as predictable features should not be specified (Sagey, 1986). Instead of distinguishing the clicks using affrication, she suggests that they should be distinguished by Place features. This argument is premised upon Beach (1938)'s palatograms of clicks in Nama and Korana, which show that more of the palate is touched in the production of the palatal click [ǂ] than in the production of the dental click [ǀ]. Sagey thus classifies the dental click as [-distributed] and the palatal click as [+distributed], and both as [+anterior]. The [distributed] feature is sufficient to distinguish between the two clicks, making any additional degree of closure features redundant. To distinguish clicks by a [continuant] feature would "falsely attribute phonological significance to the degree of closure, which seems to be universally predictable from the place features" (Sagey, 1986, p. 159). Sagey suggests that the combination of [+anterior, -distributed] with an ingressive airstream always results in affrication, making affrication phonetically predictable.

The two alveolar clicks, (post)alveolar [!] and alveolar lateral [ǁ], are classified by Sagey as [-anterior], according to Beach (1938)'s palatograms. When distinguishing between the two alveolar clicks, Sagey argues that a [lateral] feature can be used in place of a [continuant] feature, as the affrication in a lateral click could be a phonetic by-product of a lateral release. Thus, in Nama and Korana analyses, it is not necessary to posit degree of closure features to distinguish between clicks (Sagey, 1986). Sagey's proposed distinctive features for the click 'influxes' are shown in the table below.

Table 3. Sagey (1986)'s distinctive features for click types in Nama and Korana

	[ǀ]	[ǂ]	[ǁ]	[!]
coronal	+	+	+	+
anterior	+	+	-	-
distrib.	-	+	-	-
lateral	-	-	+	-

Sagey (1986) then proposes distinctive features for Beach (1938)'s Korana click 'effluxes'. She suggests that degree of closure features are now available for use in the distinction of accompaniments, as they are not distinctive for click types. This also means that the degree of closure features can be used without having to link them to any particular articulator node, which is more typologically typical. However, she concludes that, for Nama and Korana, the accompaniments can be distinguished by glottal and nasal features alone, and that degree of closure features would still be redundant in the representation of 'effluxes' in these languages[8].

Sagey (1986) suggests a feature analysis for each of the Korana accompaniments. Beach's 'weak velar plosive efflux' is produced with some pulmonic pressure against the velar closure of the click, the release of which is, according to Sagey, a voiceless unaspirated stop. Thus, this efflux is represented as [-spread glottis, -constricted glottis]. Beach's 'strong velar affricative efflux' is produced with strong pulmonic pressure against the posterior closure, which Sagey interprets as aspiration. She notes that the aspirated non-click consonants /th/ and /kh/ alternate with the aspirated affricates [tsh] and [kxh] respectively, and that the [kxh] 'efflux' alternates with an aspirated 'efflux' [kh]. These alternations lead Sagey to propose that affrication is not a defining characteristic of any of these segments. She therefore argues that the [kh] ~ [kxh] 'efflux' should be analysed as underlying /kh/, with its affrication derived from its aspiration, thus having the features [+spread glottis, -constricted glottis]. The 'velar glottalic affricative efflux' is described by Beach (1938) as being produced with glottalic pressure against the velar closure of the click, which Sagey (1986) interprets as ejection. She argues that affrication may also be a by-product of ejection, making this click accompaniment underlyingly /kʔ/ - a velar

[8] In the next paragraphs I follow Sagey (1986)'s orthography, writing the sounds phonetically as she does. This results in aspiration being represented with a normal 'h' instead of a diacritic 'ʰ' as is now standard, and ejection being represented with a glottal stop.

stop with a glottal closure. She proposes the features [-spread glottis, +constricted glottis] to represent this ‘efflux’. She also argues that the independent phoneme recorded by Beach as [kxʔ] is underlyingly /kʔ/. These analyses achieve the following: the click accompaniments are not distinguished by degree of closure features, and affricates are eliminated from the Nama/Korana inventory, the latter of which Sagey argues cannot be underlying as they do not occur without aspiration or glottalization. This leaves a three-way distinction for stops, creating a plain, aspirated, and glottalized stop series (Sagey, 1986).

In the other accompaniments – Beach’s glottal plosive, glottal fricative, and nasal effluxes – there is no audible release of the velar closure. Sagey (1986) states that, for the release of a closure to be audible, there must be air pressure against the closure which will cause a burst when released. The lack of an audible velar burst in these accompaniments is then indicative of there being no air pressure against the velar closure. Sagey offers two explanations for this lack of pressure: either the pulmonic airflow is stopped at the glottis or there is pulmonic venting through the nose for the duration of the click. She investigates these explanations through her analysis of the remaining accompaniments. For the ‘glottal plosive efflux’, Sagey (1986) follows Beach (1938) in describing this accompaniment as resulting from the release of a glottal closure – against which pulmonic air had been pressed – after both the anterior and velar closures had been released. The velar closure is released silently. The ‘glottal fricative efflux’ was described by (Beach, 1938, p. 86) as a silent velar release followed by glottal fricative [h], within which “the efflux does not commence until the velar closure is released”. Beach criticises previous descriptions of this sound as aspiration following a glottal stop, and Sagey (1986) further critiques this description, as it necessitates the ‘efflux’ being classified as both [+spread glottis] and [+constricted glottis], which she claims is articulatorily impossible. Sagey argues that the analysis of this sound as a glottal plosive followed by a glottal fricative wrongly attributes the inaudible velar release to stoppage of pulmonic air at the glottis. She cites Ladefoged and Traill (1980) who argue that the inaudible velar release is due to nasal venting. Sagey refers to their findings when measuring pulmonic egressive airflow through the nose and mouth and pharyngeal pressure during the production of Nama clicks and accompaniments. Clicks with an audible velar release produced no nasal airflow and showed an increased pharyngeal pressure, both of which are expected when the oral and nasal cavities are closed off while there is still pulmonic egressive airflow (Sagey, 1986). Sagey therefore characterises these segments as [-nasal]. Click accompaniments with no audible velar release were found to be produced with nasal airflow, accompanied by vibration of the vocal cords in the case of the nasal ‘efflux’ and no vibration in the case of the glottal plosive and fricative ‘effluxes’. These accompaniments also showed no increase in pharyngeal pressure during production of the ‘influx’ or ‘efflux’. Sagey (1986) concludes that these segments use nasal venting instead of a glottal closure to cause a silent velar release. Further evidence for this assertion exists in the observations of clicks with glottal plosives and fricatives becoming prenasalised when produced after a vowel in rapid speech (Sagey, 1986). She characterises the voiceless nasal ‘effluxes’ as [+nasal]. The ‘nasal efflux’ is considered by Sagey (1986) to be [+nasal] and [-spread glottis, - constricted glottis]. The table below, from Sagey (1986), summarises her features for Korana ‘effluxes’. I include a key so that Sagey’s sound symbols may be paired with Beach (1938)’s descriptions of each accompaniment.

Table 4. Sagey (1986)'s table of distinctive features for Korana click 'effluxes'

	k	kh	k?	ŋ	ŋh	ŋ?
Dorsal	+	+	+	+	+	+
Spread Glottis	-	+	-	-	+	-
Constr. Glottis	-	-	+	-	-	+
Nasal	-	-	-	+	+	+

k = “weak velar plosive”, kh = “strong velar affricative”, k? = “velar glottalic affricative”, ŋ = “nasal”, ŋh = “glottal fricative”, ŋ? = “glottal plosive”

This analysis leads to a simple distinctive system for Korana click accompaniments: accompaniments are divided into oral and nasal subsets with each subset having a plain, an aspirated, and a glottalised type.

Thus, Sagey (1986) concludes that i) all Nama/Korana clicks involve a velar closure; ii) affrication is not distinctive for clicks as it is predictable from the segment’s glottal features, with [+spread glottis] and [+constricted glottis] both conditioning affrication; iii) accompaniments may be nasal or oral, where oral accompaniments have an audible velar release and nasal accompaniments have an inaudible velar release; and iv) all clicks in Nama/Korana are [-continuant], as there is no evidence for degree of closure features being distinctive.

3.2.3.3 Complex segments in !Xun

Sagey (1986) analyses !Xun clicks using data from Snyman (1970). She argues that the basic click types in !Xun are phonetically similar to those in Nama and Korana and may be represented with the same features. However, !Xun has fourteen accompaniments, and glottal and nasal features are not sufficient to distinguish them. The features used for Nama and Korana and a voicing contrast leave two pairs of !Xun accompaniments undifferentiated – [k] and [kx], and [kʔ] and [kxʔ]. Thus, Sagey (1986) argues, !Xun is unlike Nama/Korana in that affrication of the velar release is not phonetically predicted by glottalization or aspiration. Furthermore, there is a plain aspirated accompaniment [kh], and the existence of this sound prevents the use of [+spread glottis] as a distinctive feature of the affricated [kx] accompaniment. In the same vein, the existence of [kʔ] precludes the use of [+constricted glottis] to derive affrication in [kx]. Sagey also notes that, in !Xun, there is no phonetic evidence that suggests that [kx] is either aspirated or glottalized. To distinguish between these 'effluxes', Sagey adds a degree of closure specification. She categorises [kx] and [kxʔ] as contours of [-continuant, +continuant]. This results in all accompaniments having a unique feature representation.

Crucial to this analysis is that the [continuant] feature is represented outside of the place node in the feature hierarchy, aligning !Xun's proposed feature geometry with that of other languages. Sagey emphasises that the degree of closure features cannot be specified independently for each articulator, as this causes more coronovelar segments to be predicted than actually occur.

Sagey (1986) turns her analysis to non-click !Xun consonants such as [tx] and [tsx][9], arguing that these phonemes are also complex segments with a Coronal and Dorsal articulation. In non-click coronals with velar articulations, the degree of closure is always – predictably – fricative. Thus, it is unnecessary to specify a [continuant] feature for the velar articulation. This leaves the [continuant] feature available for use in distinguishing between the coronal articulations in segments such as [tx] and [tsx]. In clicks, the anterior degree of closure is predictable from the coronal articulation, meaning that the [continuant] feature may be used to distinguish between velar articulations such as [ǂ] and [ǂx]. However, within a unified consonantal system, this results pairs of sounds that have identical representations, such as [tx] and [ǂ], and [tsx] and [ǂx]. The distinctive difference between these sounds pairs is the articulator to which the [continuant] feature is applying – the coronal articulation for non-clicks, and the dorsal articulation for clicks (Sagey, 1986). To address this problem, Sagey proposes that segments with two articulations have a major and a minor articulation, based on the notion of phonological 'primary-ness'. She defines 'primary-ness' as "an unpredictable property which must be phonologically specified"

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[9] [ts] is rendered by Sagey (1986) as [¢], which is now too obscure to use.

(Sagey, 1986, p. 201). The major articulation is the one with this primary property, and the minor articulation is the one without it. In !Xun, the primary – or major – articulator is the articulator to which the degree of closure features apply and are distinctive. The minor articulator is the articulator which has predictable [continuant] features. Therefore, Sagey posits that clicks have a major Dorsal articulation and non-clicks have a major Coronal articulation. She suggests that this major feature is represented in a feature diagram by an arrow beginning at the root node and pointing to the relevant articulator node, as this is a relational property rather than a property of any one articulator. To represent it otherwise would be to incorrectly imply that this property will spread during Place assimilation (Sagey, 1986). If the major/minor features are incorporated into a !Xun analysis, Sagey states that the need for a [suction] feature – as suggested by Chomsky and Halle (1968) and Traill (1985) – falls away. Although one could assume that [+suction] implies that [continuant] features apply to the velar closure and that [-suction] implies that [continuant] features apply to the coronal closure, Sagey argues that languages do not contrast segments based solely on [suction] – !Xun click and non-click coronovelars also contrast [continuant] features on the dorsal articulation. She argues that the major/minor analysis "predicts [sic] a difference in the degree of closure between clicks and non-clicks, since the crucial distinction between them is in the choice of major articulator, which is merely the articulator to which the degree of closure features apply" (Sagey, 1986, p. 259). She also asserts that the major/minor analysis has more cross-linguistic applications than a suction analysis.

3.2.4 Ladefoged and Traill (1994)

Although this paper is mostly concerned with phonetics, Ladefoged and Traill (1994) make some phonological claims that are important in further analyses of Khoisan-group languages.

Ladefoged and Traill (1994) argue that click types are not distingushed by coronal place of articulation, but instead by the part of the tongue used to create the anterior closure. They classify [!] and [||] as apical and [|] and [ǂ] as laminal. The apical clicks are distinct from one another in that [!] is central and [||] is lateral. The laminal clicks are distinguished by the place of closure – the blade of the tongue forms a closure at the teeth in the production of [|] and a closure that "always extends further back into the palatal region" in the production of [ǂ] (Ladefoged & Traill, 1994, p. 39).

Ladefoged and Traill (1994) also draw a distinction between 'abrupt' and 'noisy' clicks. Abrupt clicks – [!] and [ǂ] – have short, intense release bursts, and noisy clicks – [ʘ], [|], [||] – have longer, turbulent release bursts. Ladefoged and Traill compare the abrupt clicks to plain, egressive stops like [t] and [k] and compare the noisy clicks to homorganic affricates.

They divide clicks once more into ‘grave’ and ‘acute’ clicks, using acoustic waveforms. Dental and palatal clicks show more high frequency energy and are therefore acute, while (post)alveolar and alveolar lateral clicks show more low frequency energy and are classified as grave. The bilabial click shows an energy distribution that spans across high and low frequencies on a spectrogram, although it is still classified as a grave click by Ladefoged and Traill. By making the distinction between acute and grave clicks, Ladefoged and Traill state that it is now apparent that “the acute clicks [|, ǂ] are acoustically related to other acute consonants like [t, s] and the grave clicks [Θ, ||, !] are acoustically related to other grave consonants like [p, k]” (Ladefoged & Traill, 1994, p. 44). They further distinguish bilabial clicks from all other click types by classifying the former as ‘diffuse’ and the latter set of clicks as ‘compact’, referring to the spread of energy across frequencies in spectrograms.

The classifications derived from these acoustic properties are formulated as ‘acoustic features’, which are used to distinguish the click types from one another, as illustrated by Ladefoged and Traill (1994)’s table below.

Table 5. Ladefoged and Traill (1994)'s distinctive acoustic features for click types

TABLE III. Summary of three acoustic features of clicks

	⊙	ǀ	ǁ	ǂ	!
Grave	+	−	+	−	+
Compact	−	+	+	+	+
Noisy	+	+	+	−	−

3.2.5 Halle (1995)

Halle (1995) offers an analysis of click sounds that opposes the previous assumptions of clicks as segments with two articulations – Dorsal and either Coronal or Labial. He follows Chomsky and Halle (1968) and Ladefoged and Traill (1994) in characterising clicks as having a [+suction] feature, but argues that this feature makes the specification of two articulators unnecessary. He argues that clicks should be analysed as having only one designated articulator, and that “the second closure present in clicks is the phonetic implementation of the feature [+suction]” (Halle, 1995, p. 8). Halle states that clicks should be analysed as ‘ordinary’ consonants – that is, egressive pulmonic consonants – with a [+suction] feature. He preserves Ladefoged and Traill (1994)'s [abrupt] feature in his analysis of clicks.

Halle notes that naming clicks by their anterior closure suggests that all clicks – except the bilabial click – are Coronal, which creates a typologically unusual gap for Dorsal consonants of this class. He argues that, if clicks are treated like egressive consonants, it is expected that there be Labial, Coronal and Dorsal clicks. Halle states that the frequency spectra of Dorsal consonants have "marked energy peaks in the region between 1 and 2 kHz" (Halle, 1995, p. 9), which do not occur in Labial or Coronal consonants. The alveolar lateral and (post)alveolar clicks show similar spectral patterns, leading Halle to argue that these clicks should be characterised as Dorsal and the other non-bilabial clicks – dental, and palatal, which do not have similar energy peaks – should be classified as Coronal. The bilabial click is classified as having a Bilabial place of articulation (Halle, 1995).

Halle (1995) uses click loss data as further evidence for this analysis. Traill (1986) stated that click loss only affected the abrupt palatal and (post)alveolar clicks. Traill observed that palatal clicks tended to be replaced by the palatal plosive [c] which is [-anterior, +distributed] or by dental affricates that were [±anterior, +distributed], and that (post)alveolar clicks tended to be replaced by velar consonants. Therefore, Halle argues, click loss can simply be explained by the loss of the [+suction] feature, with all other features – especially those of the designated articulator – are retained.

Halle (1995) further proposes that all clicks be classified as [+high] to capture the Dorsal closure necessary for click production and to show their status as a 'velarized consonant'.

Therefore, in summary, the basic click types are all are specified for [+high], and are distinguished by three features. A [+abrupt] feature characterises the palatal and (post)alveolar clicks and the bilabial, alveolar lateral, and dental clicks are characterised by [-abrupt]. The dental and lateral clicks are [+anterior] and the palatal and (post)alveolar clicks are [-anterior]. Finally, the designated articulator feature is necessary to distinguish between dental and alveolar lateral clicks, and between palatal and (post)alveolar clicks. These click pairs are featurally indistinct without this specification. The designated articulatory feature classifies the (post)alveolar and lateral clicks as Dorsal, the palatal and dental clicks as Coronal, and the bilabial click as Labial (Halle, 1995). In this way, Halle (1995) analyses clicks as having one phonological Place of Articulation, with [+suction] causing the second closure.

3.2.6 Nakagawa (2006)

Nakagawa (2006) suggests the following featural analysis for an integrated consonantal system in G|ui, including Place of Articulation features, Manner of Articulation features, an acoustic [grave] feature, and a [click] feature.

Nakagawa argues that a [coronal] feature groups plain egressive plosives with plain clicks. Subsequently, these coronal stops are divided into [apical] and [palatal] sounds. The [+apical] feature groups all clicks with an alveolar 'influx' – that is, clicks with a [!] or [||] component. The [+palatal] feature distinguishes between all [+palatal] consonants, such as palatal clicks and palatal non-click plosives, and all other [-palatal] coronals. This analysis assumes that the anterior closure for all clicks is phonologically salient (Nakagawa, 2006). Nakagawa (2006) then follows Chomsky and Halle (1968) in positing that clicks and non-clicks may be divided by an [±affricated] feature, using [+affricated] for dental clicks and alveolar lateral clicks, and [-affricated] for palatal clicks and (post)alveolar clicks. A [±lateral] feature distinguishes the alveolar lateral click from the (post)alveolar click. Nakagawa (2006) uses a [grave] feature to distinguish [+grave] apical clicks from [-grave] laminal clicks. Finally, Nakagawa (2006) posits a [click] feature, equivalent to Chomsky and Halle (1968)'s [suction] feature, which serves to distinguish clicks from non-clicks.

3.2.7 Bennett (2014)

Bennett (2014) assesses the claim that clicks have two Places of Articulation. While clicks undoubtedly have two closures, Bennett argues that this does not necessarily mean that both closures are similarly phonologically active. He investigates claims about a contrastive back closure and the BVC.

A contrastive back closure has been claimed to exist in languages such as !Xóõ, where minimal pairs are reported to differ only by a velar or uvular back closure. This contrast has been interpreted as evidence for a phonologically active [Dorsal] feature as [velar] and [uvular] features are only able to be attributed to [Dorsal] sounds. However, subsequent research (Miller, Brugman, et al., 2007; Miller et al., 2009; Miller, Namaseb, et al., 2007) showed that the location of the back closure for both 'velar' and 'uvular' clicks tended to be post-velar, and also varied based on the position of the front closure of the click. The distinction between 'velar' and 'uvular' clicks seems to stem from the presence or absence of a dorsal release burst, where 'velar' clicks had an inaudible burst and 'uvular' clicks had an audible one. This was analysed as a difference in airstream features – clicks with an inaudible burst were characterised as having a lingual airstream and clicks with an audible release burst were characterised as having a linguo-pulmonic airstream. As the constrast between the two is no longer a place distinction, it does not provide evidence for the back closure of a click having its own place features (Bennett, 2014).

Bennett (2014) also argues that the BVC is not necessarily a phonological phenomenon. Rather, it can be interpreted as a phonetic constraint caused by co-articulation between clicks and vowels. A small study of one Khoekhoe speaker by Miller, Namaseb, et al. (2007) found that the posterior closure of the palatal click extends into the upper pharynx and is further back than that of the (post)alveolar click, which they assume to be uvular. Furthermore, [i] is observed as co-occurring with the palatal click, but not with the (post)alveolar click, which tends to be followed by [əi]. They argue that this is due to physiological constraints due to tongue shape in the production of these clicks and vowels, rather than a phonological BVC. Bennet (2014) argues that this study shows that the location of the posterior closure is not contrastive as it results from the difference in tongue body shape needed to form the various anterior click closures (Miller, Namaseb, et al., 2007). This could cause co-articulation that affects the following vowel. Thus, the BVC could be the direct result of a physiological restriction and is not sufficient evidence for a [Dorsal] place feature in clicks (Bennett, 2014).

3.3 Unit versus cluster analyses of sound sequences in Kalahari Basin Area languages

One of the questions central to a formal analysis of click consonants are whether clicks with two release bursts – such as clicks with a dorsal fricative or affricate accompaniment, a uvular plosive accompaniment, or a glottal obstruent accompaniment – are complex segments or consonant clusters. Although clicks are not the only segments in Khoisan-group languages that have dubious phonological status as clusters or complex segments, the non-click complex/cluster segments have not been the focus of much investigation. However, within an integrated consonant system where ingressive and egressive consonants are treated similarly, the segment analyses of clicks should be extended to the complex/cluster non-click segments. In the following sections, the broad arguments about cluster *vs* unit analyses are represented, as well as their application to non-click consonants in a cross-KBA language analysis. I use the term ‘sound sequences’ to refer neutrally to sounds that may be analysed as complex segments or clusters.

In earlier works documenting Khoisan-group phonetics and phonology (Beach, 1938; Snyman, 1970), all clicks are described as phonemes, sounds that are made up of multiple phonetic segments but are phonological entities (Snyman, 1978). Sagey (1986)'s thesis on non-linear phonology classifies all clicks as complex segments with two Place features, and classifies clicks with a second release burst as contour segments. Traill (1985) uses the unit analysis in his seminal study of !Xóõ, but remarks that a cluster analysis would reduce the number of phonemes drastically and that this would eliminate "the typological bizarreness of its consonant inventory" (Traill, 1985, p. viii). This observation was the catalyst for formal analyses that represented click sounds with two release bursts as clusters.

For the most part, it is a typological concern that has prompted recent analysis of clicks as clusters rather than complex segments. Under a unit analysis, many Khoisan-group languages are typological outliers when it comes to the size of their consonant inventory. A cluster analysis brings these languages into ranges that are more typical cross-linguistically. Proposals for various kinds of cluster analyses are described in section 3.3.1.

The cluster analysis is rebutted by Miller and others (2010, 2011; Miller, Brugman, et al., 2007; Miller et al., 2009), who argue that clicks are complex or contour segments. These arguments are set out in subsection 3.3.2. Central to both Miller's and Güldemann's arguments is the motivation for one unified consonantal system within an academic tradition that has kept click consonants separate from non-click consonants. However, their means for achieving this are vastly different.

3.3.1 Cluster analyses

Cluster analysis proposals tend to revolve around three key arguments. The first is that a cluster analysis reduces the consonant inventory of Khoisan-group languages into typical typological ranges. The second is that there are distributional and phonological parallels between the click and non-click consonant inventories of Khoisan-group languages, and the third is that these parallels imply that all sounds could be analysed under one cohesive system where clicks and non-click phonemes may form clusters.

These key arguments are described in this section, through the investigation of specific proposals for cluster analyses by Güldemann (2001), Nakagawa (2006), and – briefly – Bradfield (2014). Updated forms of the cluster analysis in recent papers by Güldemann and Nakagawa (2018) and Nakagawa, Witzlack-Makarevich, et al. (2023) are also addressed.

3.3.1.1 Güldemann (2001)

The first argument made by Güldemann (2001) is the typological one. He states that the consonant inventories of Khoisan-group languages are ‘abnormally large’. This is based on a statement by Traill (1985) which notes that !Xóõ has a consonant inventory of 117 if a unit analysis is assumed. Both Traill and Güldemann find this to be typologically unusual and argue that a cluster analysis drastically reduces the cluster inventory and brings it into more typical typological ranges.

Güldemann’s chief concern is the apparent parallels between click and non-click – or ingressive and egressive – consonants. One of the central hypotheses in Güldemann (2001) is that the ingressive and egressive consonants in Khoisan-group language inventories are able to be integrated into one system. He argues that clicks behave like stops and nasals, and that the basic difference between clicks and pulmonic stops/nasals is the difference in airstream. Thus, clicks are merely pulmonic stops with suction. Güldemann uses the !Xóõ inventory to demonstrate the similarity between clicks and pulmonic stops/nasals. Güldemann observes that stops – that is, plosives and affricates – make up the majority of the egressive consonant system of !Xóõ and allow for the most phonetic elaboration. Clicks show similar patterns of phonetic elaboration and are analogous to egressive stops in distribution and size of inventory.

Güldemann (2001) distinguishes three kinds of segments within the class of stops: simple segments, complex segments, and cluster segments. Simple segments include voiceless and voiced consonants without any phonetic elaboration. Complex consonants are made up of aspirated and ejective stops, both treated by Güldemann as having glottal phonation types. Clusters are sequences of “two consonantal constituents having phoneme status as independent segments which join together in one, more elaborate segment” (Güldemann, 2001, p. 8). He uses the terms ‘onset’ and ‘offset’ to distinguish between the initial and final constituents of the cluster. Güldemann finds two offsets used in combination with pulmonic onsets in !Xóõ, the fricative [x] and the ejective [kx’]. Clicks have additional possible offsets. He argues that the subcategorisation of stops into simple, complex, and cluster segments applies to both egressive stops and clicks.

Table 6 below is Güldemann (2001)’s ‘Integrated cross-Khoisan consonant chart’, which is supposed to represent the maximal set of consonants that a Khoisan-group language could have. The integration of the egressive and ingressive consonants requires positing correspondences between clicks and stops. Güldemann (2001) therefore represents clicks as the ingressive counterpart to certain egressive stop consonants. His hypothesised correspondences are described below the table.

Table 6. Güldemann (2001)'s Integrated cross-Khoisan consonant chart

<table>
<tr><th></th><th>EGR
Lb</th><th>EGR
Al</th><th>EGR
Al-Af</th><th>EGR
Pl</th><th>IGR
Lt</th><th>IGR
Dt</th><th>IGR
Al</th><th>IGR
Pl</th><th>IGR
Lb</th><th>EGR
Vl</th><th>EGR
Uv</th><th>EGR
Gl</th></tr>
<tr><td>Non-nasal sonorants</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Plain</td><td>w</td><td>l/r</td><td></td><td>y</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Fricatives</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Plain
Voiced</td><td>f
v</td><td>s
z</td><td></td><td>c
j</td><td></td><td></td><td></td><td></td><td></td><td>x</td><td></td><td>h</td></tr>
<tr><td>Simple stops</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Plain
Voiced</td><td>p
b</td><td>t
d</td><td>ts
dz</td><td>tc
dj</td><td>‖
g‖</td><td>|
g|</td><td>!
g!</td><td>ǂ
gǂ</td><td>⊙
g⊙</td><td>k
g</td><td>q
gq</td><td>'</td></tr>
<tr><td>Complex stops</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Plain + Gl
Voiced + Gl</td><td></td><td>t'</td><td>ts'
dz'</td><td>tc'
dj'</td><td>‖'</td><td>|'</td><td>!'</td><td>ǂ'</td><td>⊙'</td><td>k(x)'
g(x)'</td><td>q'</td><td></td></tr>
<tr><td>Plain + As
Voiced + As</td><td>ph
bh</td><td>th
dh</td><td>tsh
dzh</td><td>tch
djh</td><td>‖h
g‖h</td><td>|h
g|h</td><td>!h
g!h</td><td>ǂh
gǂh</td><td>⊙h
g⊙h</td><td>kh
gh</td><td>qh
gqh</td><td></td></tr>
<tr><td>Stop clusters</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Plain + /x/
Voiced + /x/</td><td></td><td>tx
dx</td><td>tsx
dzx</td><td>tcx
djx</td><td>‖x
g‖x</td><td>|x
g|x</td><td>!x
g!x</td><td>ǂx
gǂx</td><td>⊙x
g⊙x</td><td></td><td></td><td></td></tr>
<tr><td>Plain + /q/
Voiced + /q/</td><td></td><td></td><td></td><td></td><td>‖q
g‖q</td><td>|q
g|q</td><td>!q
g!q</td><td>ǂq
gǂq</td><td>⊙q
g⊙q</td><td></td><td></td><td></td></tr>
<tr><td>Plain + /kh/
Voiced + /kh/</td><td></td><td></td><td></td><td></td><td>‖kh
g‖kh</td><td>|kh
g|kh</td><td>!kh
g!kh</td><td>ǂkh
gǂkh</td><td>⊙kh
g⊙kh</td><td></td><td></td><td></td></tr>
<tr><td>Plain + /qh/</td><td></td><td></td><td></td><td></td><td>‖qh</td><td>|qh</td><td>!qh</td><td>ǂqh</td><td>⊙qh</td><td></td><td></td><td></td></tr>
<tr><td>Plain + /k(x)'/
Voiced + /k(x)'/</td><td>px'</td><td>tx'
dx'</td><td>tsx'
dzx'</td><td></td><td>‖x'
g‖x'</td><td>|x'
g|x'</td><td>!x'
g!x'</td><td>ǂx'
gǂx'</td><td>⊙x'
g⊙x'</td><td></td><td></td><td></td></tr>
<tr><td>Plain + /k'/</td><td></td><td></td><td></td><td></td><td>‖k'</td><td>|k'</td><td>!k'</td><td>ǂk'</td><td>⊙k'</td><td></td><td></td><td></td></tr>
<tr><td>Plain + /q'/</td><td></td><td></td><td></td><td></td><td>‖q'</td><td>|q'</td><td>!q'</td><td>ǂq'</td><td>⊙q'</td><td></td><td></td><td></td></tr>
<tr><td>Simple nasals</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Plain
Voiceless</td><td>m</td><td>n</td><td></td><td>ny</td><td>n‖
nh‖</td><td>n|
nh|</td><td>n!
nh!</td><td>nǂ
nhǂ</td><td>n⊙
nh⊙</td><td>ng</td><td></td><td></td></tr>
<tr><td>Complex nasals</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Plain + Gl</td><td>'m</td><td>'n</td><td></td><td></td><td>'n‖</td><td>'n|</td><td>'n!</td><td>'nǂ</td><td>'n⊙</td><td></td><td></td><td></td></tr>
</table>

EGR = egressive, IGR = ingressive, Lb = labial, Al = alveolar, Al-Af = alveolar affricate, Pl = palatal, Lt = lateral, Dt = dental, Vl = velar, Uv = uvular, Gl = glottal. and As = aspiration.

From this table, it is evident that the class of 'Simple stops' includes voiceless clicks, voiced clicks, and plain voiced and voiceless stops. The two types of 'Complex stops' are aspirated stops ('Plain + As') and ejective stops ('Plain + Gl'), which find their ingressive counterparts in aspirated clicks and glottalised clicks respectively. Güldemann notes that these glottalised consonants may be analysed phonologically as clusters as well, given that the glottal stop and glottal fricative often do occur as individual phonemes in Khoisan-group languages. However, he continues to classify aspirated and glottalised segments as complex segments rather than clusters. Furthermore, Güldemann includes nasal clicks in the class of ‘Simple nasals’, and preglottalised nasal stops and clicks in the class of ‘Complex nasals’. Due to this categorisation, the simple and complex clicks in Güldemann’s table are, therefore, phonological units.

Then, there are various kinds of ‘Stop clusters’, the offsets of which are /x/, /q/, /kh/, /qh/, /k(x)’/, /k’/, and /q’/. The initial segments of these clusters are mostly clicks, and there are very few egressive counterparts for the ingressive segments of this section. However, this grouping does allow Güldemann to propose that, in an integrated consonant system of !Xóõ, the same phonetic elaborations (that is, voicing, glottalization, aspiration, and a cluster offset of /kx’/ or /x/) found with egressive consonants are also found on ingressive consonants.

Therefore, Güldemann (2001) provides an integrated consonant chart that is founded on the assumption that clicks are not strange, outlier phonemes, but are phonemes that can be represented and analysed within the same system as egressive consonants.

3.3.1.2 Nakagawa (2006)

Nakagawa (2006) sets out two forms of the cluster analysis for sound sequences in G|ui, which he refers to as the ‘Moderate Cluster Analysis’ (MCA) and the ‘Radical Cluster Analysis’ (RCA). The MCA proposes that there are a limited number of unitary clicks, and that other click sounds are clusters of a unitary click and a pulmonic consonant. The RCA proposes that there is one ‘basic’ click and that all other click sounds are made up of this click plus other accompaniments. He proposes the RCA primarily to demonstrate the rationale of the MCA.

Table 7 and Table 8, represented below, are taken from Nakagawa (2006)’s paper and show the egressive and ingressive consonant inventories, respectively. His orthographic representation is maintained here. He follows Güldemann (2001)’s classification of stops into simple stops, complex stops, and stop clusters.

Table 7. Nakagawa's (2006) non-click consonant inventory for G|ui

		labial	"alveolar"		palatal	velar	uvular		glottal
Stops	<u>simple type</u>								
	plain series	p	t	ts	c	k	q		ʔ
	voiced series	b	d	dz	ɟ	g	ɢ		
	<u>complex type</u>								
	aspirated series	p^h	t^h	ts^h	c^h	k^h	q^h		
	ejective series		t'	ts'	c'	k'	q'	qχ'	
	<u>cluster type</u>								
	plain+/χ/ series		tχ	tsχ					
	plain+/qχ'/ series		tqχ'	tsqχ'					
Nasals	<u>simple type</u>								
	plain series	m	n						
Fricatives	<u>simple type</u>								
	plain series		s				χ		h
Non-nasal sonorants	<u>simple type</u>								
	plain series	w	r		j				

Table 8. Nakagawa's (2006) click consonant inventory for G|ui

		Laminal		Apical	
	<u>Type</u> Series	Dental	Palatal	Alveolar	Lateral
Stops	<u>simple</u>				
	plain	kǀ	kǂ	k!	kǁ
	voiced	gǀ	gǂ	g!	gǁ
	<u>complex</u>				
	aspirated	$kǀ^h$	$kǂ^h$	$k!^h$	$kǁ^h$
	ejective	kǀ'	kǂ'	k!'	kǁ'
	<u>cluster</u>				
	plain+/χ/	kǀχ	kǂχ	k!χ	kǁχ
	plain+/qχ'/	kǀqχ'	kǂqχ'	k!qχ'	kǁqχ'
	plain+/q/	kǀq	kǂq	k!q	kǁq
	plain+/ɢ/	kǀɢ	kǂɢ	k!ɢ	kǁɢ
	plain+/q^h/	$kǀq^h$	$kǂq^h$	$k!q^h$	$kǁq^h$
	plain+/q'/	kǀq'	kǂq'	k!q'	kǁq'
	plain+/ʔ/	kǀʔ	kǂʔ	k!ʔ	kǁʔ
	plain+/h/	kǀh	kǂh	k!h	kǁh
Nasals	<u>simple</u>				
	plain	ŋǀ	ŋǂ	ŋ!	ŋǁ

In Table 8, Nakagawa's (2006) MCA classifies the first four rows and last row of clicks as units, and the rest of the clicks as clusters. This analysis is successful in that all of the pulmonic segments in the clusters are present in G|ui as individual phonemes, meeting Güldemann's (2001) definition of a cluster. Nakagawa further extends the cluster analysis to the group of 'cluster' stops in his non-click consonant inventory (Table 7), drawing a parallel between the two inventories. Thus, some clicks and all heterorganic obstruent sequences are treated as clusters.

Within a cluster analysis like the MCA, clicks and pulmonic consonants can be integrated into one unified consonant system. Nakagawa (2006) uses click loss as evidence for this. He compares lexical items in G|ui to cognate pairs in G||ana (a closely related Khoe language) that have lost their alveolar click series. The G‖ana alveolar clicks have been replaced by velar, uvular, or glottal obstruents. Nakagawa argues that this data shows that the click clusters have been reduced to just the 'offset' of the cluster. This argument implies that, at least in G||ana, click loss is a process of cluster reduction.

Contrary to the MCA, Nakagawa (2006)'s RCA interprets all clicks except the nasal click as clusters. He notes that the nasal click cannot be interpreted as [k!] plus [ŋ] as the latter does not exist as an independent phoneme in G|ui. Nakagawa (2006) argues that the RCA has the following benefits: the consonant inventory size is reduced even more than in the MCA, all accompaniments are part of the consonant inventory, and nasal venting is explained. However, he also notes several issues that pose serious challenges for the RCA. First, the denasalisation process required by the RCA is the assimilation of a [-nasal] feature, which is typologically unattested. Second, a distributional asymmetry is created when the click clusters and non-click clusters are compared under the RCA. In click clusters the onset is a nasal segment, but in non-click consonant clusters the onset is a plain stop. Finally, the RCA predicts that a non-back vowel could occur after the alveolar and lateral clicks, as they have a velar offset. This is not the case for many Tuu and Kx'a languages, where front vowels tend not to be permitted to follow alveolar and lateral clicks. Considering these factors, Nakagawa opts for the MCA. It should be noted that both cluster analyses imply a phonetic and phonological parallel between the pulmonic velar stop and the posterior closure of clicks.

3.3.1.3 Bradfield (2014)

Bradfield (2014) proposes that every click is a cluster. In this analysis, a 'basic' click – that is /ʘ | ! || ǂ/ – and an accompaniment are two phonologically separate segments. His analysis differs from the analyses described above in that Bradfield proposes that these two components cluster concurrently. Central to this analysis is the concept of simultaneity: Bradfield's components within a click sound are not ordered and are produced concurrently.

For Bradfield, even a 'plain' click, such as [!], is a cluster as it combines with a phonetically empty accompaniment segment. Thus, if a language has 20 contrastive click sounds (for example, three clicks [| ! ||] that may occur with plain, voiced, nasalised, glottalised and aspirated phonation types), under Bradfield's analysis, there are only eight phonemes that are available for combination. This decreases the number of consonants in Khoisan-group languages even more drastically than either the Moderate or Radical Cluster Analyses.

What prevents these phonemes from targeting pulmonic consonants non-discriminately is not made explicit.

3.3.1.4 Nakagawa, Witzlack-Makarevich, et al. (2023) and Güldemann and Nakagawa (2018)

Nakagawa, Witzlack-Makarevich, et al. (2023) and Güldemann and Nakagawa (2018) provide updated arguments for a cluster analysis.

Nakagawa, Witzlack-Makarevich, et al. (2023) state that a MCA brings the size of KBA language consonant inventories into a more typical typological range according to the "globally representative value range for consonant inventories as established by UPSID [UCLA Phonological Segment Inventory Database]" (Nakagawa, Witzlack-Makarevich, et al., 2023, p. 14). All of the languages included in their cross-linguistic investigation except Khoekhoe are still classified as having large consonant inventories, according to Maddieson (2013), who considers 'large' consonant inventories to be those with more than 34 consonants. However, these languages are still considered to be within the bounds of ordinary typological findings once the MCA is applied.

Nakagawa, Witzlack-Makarevich, et al. (2023) also provide a chart of all possible click root-onsets for KBA languages. Of note in this chart is that clicks with a glottal component are represented in two ways: as complex or cluster segments. This reflects a distinction made by Güldemann and Nakagawa (2018) that separates ejective clicks[10] and aspirated clicks from glottal clicks and clicks with delayed aspiration, all of which are argued to be contrastive in

[10] Found in G|ui, documented in Nakagawa (2006).

G|ui. They argue that the former are complex clicks, and the latter are clusters. That is, ejective clicks are complex clicks and are thus represented as /!ˀ/, whereas clicks with a glottal stop offset are clusters, and should be represented as /!ʔ/. The same goes for aspiration on clicks: true aspirated clicks are complex clicks, so should be represented as /!ʰ/, while clicks with delayed aspiration are clusters of a click plus a glottal fricative, so should be represented as /!h/.[11] Thus, they argue that many click sounds can be decomposed into two phonological segments and continue to support cluster analyses of these sounds.

3.3.2 Unit analysis

Since the proposal of a cluster analysis for Khoisan-group consonant inventories, few researchers have argued explicitly for the unit analysis. Most arguments for the unit analysis come from work led by Amanda Miller. These arguments will be explored below. The claims made in various papers by Miller and her colleagues are similar, so these papers will be discussed within the same subsection.

3.3.2.1 Miller, Namaseb, et al. (2007), Miller, Brugman, et al. (2007), Miller et al. (2009), and Miller (2011)

Miller et al. (2009) make several key claims about clicks in N|uu. These claims have been expanded to include clicks in languages other than N|uu (Miller, 2011). First, the term ‘accompaniment’ is outdated and that clicks can be described using the standard concepts of place, manner, and phonation. Second, clicks are distinguished from non-clicks by an airstream mechanism, and this airstream is lingual and not velaric. Third, clicks are better characterised as contour segments than clusters.

Miller et al. (2009) argue that the term ‘accompaniment’ is too broad, thus obscuring important phonological and structural information about click segments. ‘Accompaniment’ has been used to group together laryngeal, nasal, dorsal, and airstream contrasts. This grouping forms no natural class in terms of features, but rather a notional class premised upon the assumed dichotomy between ‘plain’ or basic click sounds and their phonetic elaboration. Miller et al. (2009) argue that this grouping obfuscates the parallels between certain click segments and other non-click consonants. Miller (2011, p. 416) identifies four dimensions used in capturing the phonological representation of stop consonants: “place of articulation, manner of articulation (including lateral contrasts), laryngeal setting, and nasality”. Miller argues that

[11] Here, the (post)alveolar click symbol stands in for all click types.

positional distribution patterns show that clicks behave phonologically as obstruents. Furthermore, clicks are non-continuants as they involve two complete constrictions. Thus, clicks must be represented using the same dimensions as stop consonants, plus an additional dimension: that of a non-pulmonic airstream. This analysis means that a click influx should not necessarily be considered phonologically separate from their accompaniments, as has been argued by proponents of a cluster analysis.

The articulation of clicks requires a double closure in the oral tract. Miller et al. (2009) state that the posterior closure has historically been assumed to be velar. In Ladefoged and Maddieson (1996), clicks are described as being produced with an ingressive velaric airstream. The postulation of a velar place for clicks and the term ‘velaric airstream’ contributed to the assumption that the posterior closure in clicks was phonologically relevant. This led to clicks being categorised as velar or uvular clicks: Traill and Ladefoged (1994) report that !Xóõ has a set of clicks that contrast based on the place of posterior closure, classifying some as velar and others as uvular. Nakagawa (2006) follows Traill and Ladefoged’s classification for clicks in G|ui. Miller, Namaseb, et al. (2007) challenge the assumption that the posterior closure in clicks was phonologically salient. To do so, they first propose that a better description of the airstream used in click production would be ‘lingual’. This more accurately accounts for the rarefaction in click production being a product of tongue retraction rather than velaric involvement. They then investigate whether certain clicks do actually have a velar closure, and whether clicks could contrast based solely on the place of posterior closure.

Miller, Namaseb, et al. (2007) investigated the posterior constriction of clicks in Khoekhoe and found that the posterior constriction was not velar, but post-velar. Miller, Brugman, et al. (2007) and Miller et al. (2009) investigated the same in N|uu, finding that the alveolar [!] and palatal [ǂ] clicks both have post-velar closures that differ slightly in position of the tongue root. They also investigated the possibility of a velar-uvular contrast in N|uu clicks, some of which have been noted to have a uvular burst. Miller et al. (2009) find that there is no significant difference in burst spectra between the ‘velar’ and ‘uvular’ clicks, which would have been expected if there was a true contrast in posterior place. They argue that the place of the posterior constrictions of clicks are not contrastive on their own; it is the airstream and timing of closure release that are in fact contrastive. Spectrograms of clicks that were previously categorised as velar showed both closures being released almost instantaneously, whereas clicks that were categorised as uvular had a delayed posterior closure burst. Thus, a velar/uvular place distinction was not found, but the timing of the release of the posterior burst was found to be contrastive. The crux of their argument is that clicks are not constituted phonetically of an ingressive segment plus a velar consonant, as suggested by cluster analyses such as the MCA and RCA (Nakagawa, 2006). Thus, clicks are not straightforwardly comparable to the velar consonants.

Miller (2011) argues, premised upon Sagey (1986)'s conception of complex and contour segments, that clicks are always complex segments and may also be contour segments. Thus, clicks have two places of articulation which overlap temporally, making them complex segments. Contour clicks are inherently complex (in the sense of having two articulatory constrictions) and also consist of a change from a lingual airstream to a pulmonic or glottalic one (Miller, 2011).

Nakagawa (2006) and Güldemann (2001) interpret the click + pulmonic dorsal burst sequences such as [!q] as clusters of a click plus a pulmonic plosive. Miller (2011) interprets these as single segments that have an airstream contour. Thus, a sound like [!q] is a single phoneme with two airstream features: [lingual] and [pulmonic]. Miller (2011) calls these sounds 'linguo-pulmonic stops'. She calls segments that consist phonetically of a click with velar/uvular frication, e.g. [!χ], 'linguo-pulmonic affricates'. This implies that the segments are contour segments in two ways: the first is that the airstream shifts from lingual to pulmonic during production of the segments, and the second is that the manner of articulation changes from stop to fricative within the segment, much like a pulmonic affricate. Her analysis also includes clicks with a glottalic component, such as glottalized or ejective clicks, which are characterised as 'linguo-glottalic stops/affricates'. Thus, the concept of contour segments is expanded to include segments that have two airstream features[12].

Regarding the typological argument for a cluster analysis, Miller (2011) argues that a large consonant inventory for languages using clicks is a natural by-product of using a fifth contrastive dimension – that of airstream. Furthermore, a cluster analysis causes a different kind of typological anomaly. Miller cites the cross-linguistic survey by Kreitman (2008), which suggested that there is an implicational universal regarding onset clusters: languages with OO clusters also have OS clusters, but the inverse is not true. Thus, Miller (2011) argues that the

[12] In response to this, Güldemann and Nakagawa (2018) argue that changes in airstream are not phonologically comparable to other types of contour segments, as the change between airstreams is categorical and not gradual, as change is in other contour segments.

cluster analysis of click segments creates a highly unusual typology where there are OO clusters but not OS clusters.

Miller (2011)'s analysis of certain clicks as contour segments are represented in the table below, compared to the analysis of the same segments by Güldemann (2001) and Nakagawa (2006). The (post)alveolar click symbol is used to represent all click types.

Table 9. Representation of certain click sounds within a unit analysis, a moderate cluster analysis, and the Radical Cluster Analysis.

Miller (2011)		**A moderate cluster analysis from Güldemann (2001)**		**Radical Cluster Analysis from Nakagawa (2006)**	
Symbol	**Description**	**Symbol**	**Description**	**Symbol**	**Description**
!	Lingual stop	!	Simple stop: Plain	k!	/ŋ!/ + /k/
ŋ̊!ˀ	Voiceless nasal glottalized click	!’	Complex stop: Plain + Gl.	k!ʔ	/ŋ!/ + /ʔ/
!ʰ	Aspirated click	!h	Complex stop: Plain + As.	k!h	/ŋ!/ + /h/
!͡q	Linguo-pulmonic stop	!q	Stop cluster: Plain + /q/	k!q	/ŋ!/ + /q/
!͡χ	Linguo-pulmonic affricate	!x	Stop cluster: Plain + /x/	k!χ	/ŋ!/ + /χ/
!͡χ’ !͡kx’	Linguo-glottalic affricate	!x’	Stop cluster: Plain + /k(x)’/	k!qχ	/ŋ!/ + /qχ’/

4 Materials and methods

The methodology described in the following section is designed to capture various phonetic and phonological aspects of onsets from multiple sources. A more extensive picture of the phonology of complex/cluster onsets can then be constructed. From this, the research questions pertaining to the unit or cluster status and the phonological patterns of the onsets may be answered. This chapter gives an overview of the process of data collection and analysis. Section 4.1 details the collection and organisation of the data and section 4.2 details the methods of analysis.

4.1 Data collection and organisation

The primary aim of this project is to investigate the phonological status of root-initial syllable onsets in KBA languages. This requires an examination of frequency and distribution patterns of the onsets, as well as the phonetic/phonological content of the onsets themselves. To do this, I collected data from multiple dictionary sources as well as phonetic/phonological descriptions of sound inventories in KBA languages.

Data collection was constrained by availability and reliability of dictionary sources – nothing was used that was published before 1990 to reduce the possibility of wrongly interpreting older orthographies, and dictionaries without clear orthographic guides or phonetic descriptions were also omitted. The cut-off point was 1990 as a standard representation of click types was only incorporated into the IPA in 1989 (International Phonetic Association, 1989)[13]. I also only used dictionaries with more than 1500 entries so that patterns in the frequencies of certain sounds could be calculated more reliably[14]. The languages included in my data collection were Khoekhoegowab (KHOE-KWADI, Khoekhoe branch), Khwe (KHOE-KWADI, Kalahari branch), N|uu (TUU, !Ui branch), !Xóõ (TUU, Taa branch), Ekoka !Xun (KX'A, Northwestern dialect cluster), and Ju|'hoan (KX'A, Southeastern dialect cluster).

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[13] Traill's !Xóõ dictionary (originally published in 1985) was used, but data was collected from the updated 1994 edition.

[14] Dictionaries with fewer than 1500 entries resulted in sample sizes that were too small to accurately assess distributional patterns. In future studies, such a cut-off point should be calculated around statistical significance.

I collected data from the following dictionary sources:

1. *A Khoekhoegowab Dictionary with an English-Khoekhoegowab Index* (Haacke & Eiseb, 2002)
2. *Khwe Dictionary* (Kilian-Hatz, 2003)
3. *A !Xóõ Dictionary* (Traill, 1994)
4. *N|uuki Namagowab Afrikaans English ǂXoakiǂxanisi / Mîdi di ǂKhanis / Woordeboek / Dictionary* (Sands & Jones, 2022)
5. *English – Ju|'hoan / Ju|'hoan – English Dictionary* (Dickens, 1994)
6. *A Concise Dictionary of Northwestern !Xun* (König & Heine, 2008)

Data collection from the dictionaries included recording each entry-initial onset that occurred, the number of entries beginning with that onset, as well as which vowel types followed each onset. This information was recorded in a frequency table. This included all words beginning with a consonant or possible consonant cluster; words beginning with a vowel were excluded, unless the dictionary explicitly marked these entries as beginning with a glottal stop. The type of vowel, that is, < a, e, i, o, u>, immediately following each onset was recorded so that the co-occurrence of various onsets and back or front vowels could be assessed. Where vowel sequences occurred after an onset, only the vowel immediately following the onset was recorded. As some of the languages included differentiate between vowels with different phonation types, such as breathy voiced, pharyngealised, glottalised, or nasalised vowels, information about which vowel phonation types could occur after each segment was also collected.

Certain words were excluded from the frequency count. Words beginning with nasals that were explicitly marked as syllabic were excluded. Also excluded were words where the spelling – and, therefore, orthographic representation of sounds – was uncertain, such as words occurring out of alphabetical order. For example, in Ju|'hoan, *n‖oeca* is excluded because it is found in the *n‖h* section, and not with other words beginning with *n‖*. This makes analysis of this sound uncertain.

The frequency tables are a useful source of information about the prevalence of onsets within a language, as well as the rate of co-occurrence of certain onsets and vowels. Once the frequency tables were compiled, I collected information about the phonetic and phonological content of each onset from previous descriptions of the languages so that the onset consonants could be used in a phonological analysis.

There are some limitations that arise because of this data collection method. While the amount of information acquired from the dictionaries was useful for comparing distributional patterns, this study is naturally limited by the second-hand nature of the data as one is forced to rely on the accuracy of previous transcriptions and the efficacy of any transliteration process. As noted by Bonny Sands (personal communication), vowel sequences may not always be transcribed accurately in the dictionaries, with central vowels often being transcribed as lower or higher than their actual production. This may skew the data analysis. A further limitation of this data capturing method is that only the first vowel following the onset was recorded. This simplified the data capturing process significantly but may mean that crucial information about vowels in vowel sequences was missed. This is particularly troubling regarding the Ju|'hoan data, where the vowel sequence recorded as *ai* is pronounced as [əi] or [i]. This can be rectified in future studies through a more detailed data capturing process. A further limitation is that the information about vowel phonation types is not included in the frequency tables as this information was not deemed necessary at the beginning of this project and had to be collected later once its relevance became apparent.

4.2 Analysis of data

The data have been analysed in two primary ways. The first is through Observed/Expected (O/E) ratios, which are used to compare the expected number of co-occurrences of two segments or elements with the actual number of co-occurrences. These ratios were used to investigate the occurrence of complex/cluster onsets. The second way in which the data were analysed was through comparison of the onsets to previous descriptions of the sounds in each language so that onset consonant inventories could be drawn up. Onset consonant inventories are necessary for the discussion of the phonological systems of the languages in question. Thus, previous phonetic and phonological data were used to organise the onsets into inventory tables.

4.2.1 O/E ratios

The frequency counts collected from the dictionary entries were used to investigate distributional trends in the data and to investigate the expected co-occurrence of two sounds or sound sequences. The aim of this process was to investigate the internal structure of complex/cluster onsets so that phonological conclusions may be drawn about the nature of the onsets.

O/E ratios were first used by Pierrehumbert (1993) to assess the strength of the Obligatory Contour Principle[15] (OCP) acting on consonants within verbal roots in Arabic. Pierrehumbert calculated O/E ratios by counting the number of times that two segments occurred together in the same root (the Observed value) and divided that by the number of times that the two segments would be expected to co-occur if there was no OCP effect (the Expected value). The latter is calculated by multiplying the observed instances of two individual segments and then dividing that number by the total number of roots (Gallagher & Coon, 2009). An O/E ratio of zero indicates that there may be a restriction on the co-occurrence of the segments, as none of the expected co-occurrences are observed. O/E ratios of lower than one may also indicate such a restriction. An O/E ratio of one indicates that there is no OCP effect, and that the combination of segments occurs as frequently as expected from the distribution of the individual segments (Pierrehumbert, 1993). An O/E ratio of more than one indicates that a sequence of sounds co-occurs more often than expected from the frequencies of the individual segments.

Naturally, this is not a clear diagnostic tool, although the results of O/E ratios may be useful. This method may be compromised by small datasets, and it would behove any future studies using this method to run a test of statistical significance on the results. It is, for the purposes of this study, a useful way to approach the seemingly asymmetrical frequencies of consonants and consonant sequences in KBA languages. I used O/E ratios to assess whether the consonant sequences found in KBA languages are statistically expected or unexpected if analysed as consonant clusters. For example, for sequences of consonants including [χ], such as [tχ], tsχ], or [!χ], an O/E ratio that is consistently around one may indicate that these consonant sequences are expected in a sound system that allows consonants to combine and cluster. An O/E ratio that is consistently higher than one may indicate that the frequency of occurrence of individual phonemes results in an unexpectedly high rate of clusters. This does not prove that the cluster analysis of such consonant sequences is incorrect, but it may prompt one to consider different analyses of these sounds. Below is the formula used to calculate O/E ratios in my paper, where *O* stands for the observed number of occurrences of a sound sequence (such as consonant-consonant sequence or a consonant-front vowel sequence), *n* is the total number of dictionary

[15] The Obligatory Contour Principle prohibits consecutive identical features from occurring an underlying representation (Goldsmith, 1976).

entries for a specific language, *S* stands for sound – so *S1* is the first sound in the sequence and *S2* is the second – and *E* represents the expected number of occurrences of the sequence:

$$\frac{O}{E} = \frac{O}{S1 \times S2/n}$$

An example of an O/E ratio calculation from !Xóõ is provided with the steps of the calculation evident for the sound [!x], a (post)alveolar click with a dorsal fricative accompaniment. If this sound is assumed to comprise of independent phonemes [!] as *S1* and [x] as *S2*, the O/E ratio is calculated as follows:

$O = 21$

$S1 = 132$

$S2 = 32$

$n = 3076$

$E = \frac{S1 \times S2}{n} = \frac{132 \times 32}{3076} = 1.373212$

$O/E = \frac{21}{1.373212} = 15.29261$

Thus, if the sound [!x] is comprised of two individual phonemes allowed to freely combine, one would expect to see [!x] occur 1.37 times in the dataset, but it actually occurs 21 times, yielding an O/E ratio that is higher than 1.

O/E ratios for the consonantal onsets were mostly run on voiceless onsets. This is because the voiced onsets tended to occur at lower frequencies in the datasets and so provided less information for calculations.

4.2.2 Synthesis of onset consonant inventories

The frequency tables and additional sources describing the sounds of each language were used to construct onset consonant inventories for each language. I considered the orthographic guides in the dictionaries, phonetic and phonological descriptions, and evidence for borrowings of sounds to formulate these inventories. This task is inherently fraught with complications, as any transliteration of sounds has the potential to lose or even obscure phonetic/phonological information. The potential for poor transliteration is present in every representational choice. However, no broader phonological analysis about a language can be made without the foundation of a sound inventory, so this is a crucial step in the process.

5 Data and results

In this section, the results of the data capturing and analysis are presented. Section 5.1 lays out the frequency table and selected O/E ratios for each language. These are grouped together as the O/E ratios are dependent on the frequency tables. Section 5.2 lays out the onset consonant inventories and the accompanying phonetic/phonological information for each language.

5.1 Frequency tables and O/E ratios

The frequency tables of onset consonants and O/E ratios for each language are laid out below. The tables show the number of lexical entries in every dictionary beginning with each onset. For each onset, it also shows how many times each onset is followed by a front vowel or a back vowel, yielding information which will be used to investigate the possible effect of a BVC within a language. The percentage of the total number of entries that each onset comprises is also given. Onsets occurring only in loanwords (marked on the source or clearly borrowed) are in grey. Onsets are recorded in the original orthography of the dictionary (under the heading 'Orth.') and include brief phonetic descriptions or representations of sounds as provided in the dictionaries. The order of onsets in the frequency table reflects the order in which they are listed in their respective dictionaries. If there is additional information regarding the type of vowel phonation that may follow certain onsets, I record it beneath the frequency table of the language. I use the orthography of the dictionary in the O/E calculations and represent selected O/E ratios in such a way that the observed and expected numbers of each sound sequence are apparent as well as the O/E ratio itself.

5.1.1 Khoekhoegowab

Table 10. Frequency table for word onsets in Khoekhoegowab (Haacke & Eiseb, 2002)

Onset		**Number of entries**	**Following vowel**		**% of onsets**
Orth.	**Description of sound**		**Front vowel**	**Back vowel**	
	Glottal stop [ʔ] preceding word-initial vowels	243	33	210	5,80
b, p	[p]	98	23	75	2,34
bl		2	1	1	0,05
br		4	3	1	0,10
d, t	[t]	191	44	147	4,56
dr		2	0	2	0,05
f		13	5	8	0,31

Onset		Number of entries	Following vowel		% of onsets
Orth.	**Description of sound**		**Front vowel**	**Back vowel**	
fl		5	4	1	0,12
fr		1	0	1	0,02
g, k	[k]	205	20	185	4,90
h		108	18	90	2,58
j		8	3	5	0,19
kl		6	4	2	0,14
kr		6	3	3	0,14
kh		71	2	69	1,70
l		20	8	12	0,48
m		65	20	45	1,55
n		72	9	63	1,72
pl		3	0	3	0,07
pr		9	5	4	0,21
s		204	43	161	4,87
sk		2	1	1	0,05
skr		1	0	1	0,02
sl		1	0	1	0,02
sm		1	0	1	0,02
sp		5	1	4	0,12
spr		2	1	1	0,05
st		6	1	5	0,14
str		2	0	2	0,05
sw		1	0	1	0,02
tr		6	3	3	0,14
ts		95	19	76	2,27
r		36	8	28	0,86
v		1	1		0,02
w		6	2	4	0,14
x	[x]	114	5	109	2,72
xl		1	0	1	0,02
xr		5	3	2	0,12
|	(affricated) dental click [|] followed by a glottal plosive	157	18	139	3,75
|g	[|] followed by an inaudible voiceless velar plosive	147	25	122	3,51
|h	[|] followed by a delayed glottal fricative	147	8	139	3,51
|kh	[|] followed by a voiceless velar fricative or affricate	119	21	98	2,84
|n	[|] accompanied by voiced velar nasalisation	81	6	75	1,93
!	(implosive) alveolar click [!] followed by a glottal plosive	163	9	154	3,89

Onset		Number of entries	Following vowel		% of onsets
Orth.	**Description of sound**		**Front vowel**	**Back vowel**	
!g	[!] followed by an inaudible voiceless velar plosive	183	4	179	4,37
!h	[!] followed by a delayed glottal fricative	140	1	139	3,34
!kh	[!] followed by a voiceless velar fricative or affricate	123	4	119	2,94
!n	[!] accompanied by voiced velar nasalisation	173	1	172	4,13
ǁ	(affricated) lateral click [ǁ] followed by a glottal plosive	124	7	117	2,96
ǁg	[ǁ] followed by an inaudible voiceless velar plosive	164	8	156	3,92
ǁh	[ǁ] followed by a delayed glottal fricative	108	3	105	2,58
ǁkh	[ǁ] followed by a voiceless velar fricative or affricate	102	5	97	2,44
ǁn	[ǁ] accompanied by voiced velar nasalisation	97	3	94	2,32
ǂ	(implosive) palatal click [ǂ] followed by a glottal plosive	120	15	105	2,87
ǂg	[ǂ] followed by an inaudible voiceless velar plosive	138	14	124	3,30
ǂh	[ǂ] followed by a delayed glottal fricative	107	14	93	2,56
ǂkh	[ǂ] followed by a voiceless velar fricative or affricate	76	11	65	1,82
ǂn	[ǂ] accompanied by voiced velar nasalisation	97	11	86	2,32
TOTAL		**4187**	**481**	**3706**	

It should be noted that Haacke and Eiseb (2002) represent a plain, voiceless click as a click followed by *g*, and represent glottalised clicks with just the basic click symbol.

I ran the following O/E calculations assuming clicks with voiceless nasal aspiration/delayed aspiration are clusters of a plain click + *h* and glottalised clicks are clusters of a plain click + a glottal stop:

Table 11. O/E ratios for clicks with delayed aspiration in Khoekhoegowab

Onset	ǀh	!h	ǁh	ǂh
S1	ǀg	!g	ǁg	ǂg
S2	h	h	h	h
Observed	147	140	108	107
Expected	3.79	4.72	4.23	3.56
O/E	38.77	29.66	25.53	30.06

Table 12. O/E ratios for glottalised clicks in Khoekhoegowab

Onset	ǀ	!	ǁ	ǂ
S1	ǀg	!g	ǁg	ǂg
S2	ʔ	ʔ	ʔ	ʔ
Observed	157	163	124	120
Expected	8.53	10.62	9.52	8.01
O/E	18.40	15.35	13.03	14.98

If clicks with a velar fricative/affricate release are interpreted as a cluster of a plain click + *kh*, the O/E ratios are as follows:

Table 13. O/E ratios for clicks with a velar fricative/affricate release in Khoekhoegowab

Onset	ǀkh	!kh	ǁkh	ǂkh
S1	ǀg	!g	ǁg	ǂg
S2	kh	kh	kh	kh
Observed	119	123	102	76
Expected	2.49	3.10	2.78	2.34
O/E	47.74	39.64	36.68	32.48

5.1.2 Khwe

Table 14. Frequency table for word onsets in Khwe (Kilian-Hatz, 2003)

Onset		**Number of entries**	**Vowel following onset**		**% of onsets**
Orth.	**Description**		**Front vowel**	**Back vowel**	
b		67	18	49	2,51
c	voiceless alveolar/palato-alveolar/palatal fricative (dialectal variation)	152	72	80	5,68
ckr		1	1	0	0,04
cn		1	1	0	0,04
cp		2	1	1	0,07
ct		2	0	2	0,07
ctr		1	0	1	0,04
d		69	40	39	2,58
dr		1	1	0	0,04
dj	voiced alveolar affricate	67	26	41	2,51
djw		1	0	1	0,04
f		16	3	13	0,60
fr		1	0	1	0,04
g		55	4	51	2,06
gy		30	10	20	1,12
h		40	17	23	1,50
k		143	12	131	5,35
kw		4	1	3	0,15
kx		1	0	1	0,04
kh	aspirated velar plosive	51	2	49	1,91

Onset		Number of entries	Vowel following onset		% of onsets
Orth.	Description		Front vowel	Back vowel	
khw		2	2	0	0,07
khy	palato-velar fricative	16	4	12	0,60
kx'	postvelar ejective	56	9	47	2,09
ky		55	12	43	2,06
l		3	3	0	0,11
m		89	10	79	3,33
mw		1	0	1	0,04
mb		38	6	32	1,42
mbw		2	2	0	0,07
n		28	3	25	1,05
nd		33	12	21	1,23
ndj		6	3	3	0,22
ng	prenasalised voiced velar plosive	27	2	25	1,01
ngw		4	0	4	0,15
ngy		22	8	14	0,82
ny		12	0	12	0,45
ŋ	velar nasal	6	0	6	0,22
ŋw		2	1	1	0,07
ŋy		1	0	1	0,04
p		45	14	31	1,68
pf		2	0	2	0,07
pl		2	0	2	0,07
pr		3	2	1	0,11
ph		14	4	10	0,52
q	uvular plosive	74	8	66	2,77
r		21	6	15	0,79
t		98	34	64	3,66
tr		2	0	2	0,07
t'	alveolar ejective	8	2	6	0,30
tc	voiceless alveolar affricate	101	50	51	3,78
tcw		3	2	1	0,11
tc'	alveolar fricative ejective	28	9	19	1,05
tcx	alveo-palatovelar affricate	21	3	18	0,79
th	aspirated voiceless alveolar plosive	32	5	27	1,20
tx		15	5	10	0,56
v		8	6	2	0,30
w		39	10	29	1,46
x	voiceless velar fricative	65	9	56	2,43
xl		1	0	1	0,04
xr		2	1	1	0,07
y	voiced palatal fricative	41	20	21	1,53
|	dental click [|] with voiceless velar stop accompaniment	58	14	44	2,17

Onset		Number of entries	Vowel following onset		% of onsets
Orth.	**Description**		**Front vowel**	**Back vowel**	
|'	[|] with voiceless velar stop and glottal stop accompaniment	33	7	26	1,23
|g	[|] with voiced velar plosive accompaniment	36	8	28	1,35
|h	[|] with voiceless aspirated velar stop accompaniment	19	7	12	0,71
n|	[|] with voiced nasal accompaniment	22	6	16	0,82
n|g	[|] with prenasalised voiced velar stop accompaniment	24	7	17	0,90
|q	[|] with voiceless uvular stop accompaniment	21	4	17	0,79
|x	[|] with voiceless velar affricate accompaniment	39	4	35	1,46
|x'	[|] with affricated velar ejective accompaniment	20	2	18	0,75
!	alveolar click [!] with voiceless velar stop accompaniment	16	1	15	0,60
!'	[!] with voiceless velar stop and glottal stop accompaniment	8	3	5	0,30
!h	[!] with voiceless aspirated velar stop accompaniment	5	0	5	0,19
n!	[!] with voiced nasal accompaniment	2	1	1	0,07
!q	[!] with voiceless uvular stop accompaniment	3	0	3	0,11
!x	[!] with voiceless velar affricate accompaniment	2	1	1	0,07
ǂ	palatal click [ǂ] with voiceless velar stop accompaniment	71	21	50	2,66
ǂ'	[ǂ] with voiceless velar stop and glottal stop accompaniment	40	9	31	1,50
ǂg	[ǂ] with voiced velar plosive accompaniment	26	8	18	0,97
ǂh	[ǂ] with voiceless aspirated velar stop accompaniment	25	5	20	0,93
nǂ	[ǂ] with voiced nasal accompaniment	15	0	15	0,56
nǂg	[ǂ] with prenasalised voiced velar stop accompaniment	17	4	13	0,64
ǂq	[ǂ] with voiceless uvular stop accompaniment	47	7	40	1,76
ǂx	[ǂ] with voiceless velar affricate accompaniment	29	7	22	1,08
ǂx'	[ǂ] with affricated velar ejective accompaniment	16	6	10	0,60

Onset		Number of entries	Vowel following onset		% of onsets
Orth.	**Description**		**Front vowel**	**Back vowel**	
ǁ	lateral click [ǁ] with voiceless velar stop accompaniment	94	16	78	3,52
ǁ'	[ǁ] with voiceless velar stop and glottal stop accompaniment	48	8	40	1,80
ǁg	[ǁ] with voiced velar plosive accompaniment	41	8	33	1,53
ǁh	[ǁ] with voiceless aspirated velar stop accompaniment	21	3	18	0,79
nǁ	[ǁ] with voiced nasal accompaniment	10	0	10	0,37
nǁg	[ǁ] with prenasalised voiced velar stop accompaniment	21	4	17	0,79
ǁq	[ǁ] with voiceless uvular stop accompaniment	36	7	29	1,35
ǁx	[ǁ] with voiceless velar affricate accompaniment	54	15	39	2,02
ǁx'	[ǁ] with affricated velar ejective accompaniment	22	2	20	0,82
TOTAL		**2674**	**671**	**2013**	

I ran O/E ratios for the following consonant sequences, assuming that they are clusters: stops + *x*, clicks + *x'* (assuming the second sound is *kx'*), and clicks + *q*.

Table 15. O/E ratios for sounds with velar affricate/fricative component in Khwe

Onset	ǀx	!x	ǁx	ǂx	tx	tcx
S1	ǀ	!	ǁ	ǂ	t	tc
S2	x	x	x	x	x	x
Observed	39	2	54	29	15	21
Expected	1.41	0.39	2.28	1.73	2.38	2.46
O/E	27.66	5.14	23.63	16.80	6.30	8.55

Table 16. O/E ratios for clicks with affricated velar ejective accompaniment in Khwe

Onset	ǀx'	ǁx'	ǂx'
S1	ǀ	ǁ	ǂ
S2	kx'	kx'	kx'
Observed	20	22	16
Expected	1.21	1.97	1.49
O/E	16.47	11.18	10.76

Table 17. O/E ratios for clicks with a uvular stop accompaniment in Khwe

Onset	|q	!q	ǁq	ǂq
S1	|	!	ǁ	ǂ
S2	q	q	q	q
Observed	21	3	36	47
Expected	1.61	0.44	2.60	1.96
O/E	13.08	6.78	13.84	23.92

5.1.3 !Xóõ

Table 18. Frequency table for word onsets in !Xóõ (Traill, 1994)

Onset		**Number of entries**	**Following vowel**		**% of onsets**
Orth.	**IPA**		**Front vowel**	**Back vowel**	
ʘ	labial click with friction [ʘ]	13	0	13	0,42
ʘg	voiced [ʘ]	6	0	6	0,20
ʘx	[ʘ] + voiceless velar fricative	2	0	2	0,07
gʘx	voiced [ʘ] + voiceless velar fricative	1	0	1	0,03
ʘkx'	[ʘ] + velar ejective	1	0	1	0,03
gʘkx'	voiced [ʘ] + velar ejective	2	0	2	0,07
ʘq	[ʘ] + uvular stop	5	0	5	0,16
ʘɢ	voiced [ʘ] + uvular stop	3	0	3	0,10
ʘqh	[ʘ] with aspirated stop	6	0	6	0,20
gʘqh	voiced [ʘ] with aspirated stop	2	0	2	0,07
ʘq'	[ʘ] with uvular ejective	3	0	3	0,10
ʘh	[ʘ] with delayed aspiration	8	0	8	0,26
ʘn̥	[ʘ] with voiceless nasal	1	0	1	0,03
ʘn	[ʘ] with voiced nasal	9	0	9	0,29
ˀʘn	[ʘ] with pre-glottalised nasal	2	0	2	0,07
ʘ'	[ʘ] with glottal stop	5	0	5	0,16
|	dental click with friction [|]	76	5	71	2,47
|g	voiced [|]	58	0	58	1,89
|x	[|] + voiceless velar fricative	17	0	17	0,55
g|x	voiced [|] + voiceless velar fricative	10	0	10	0,33
|kx'	[|] + velar ejective	7	0	7	0,23
g|kx'	voiced [|] + velar ejective	9	0	9	0,29
|q	[|] + uvular stop	15	0	15	0,49
|ɢ [ɴ|ɢ]	voiced [|] + uvular stop	30	0	30	0,98
|qh	[|] with aspirated stop	29	2	27	0,94
g|qh	voiced [|] with aspirated stop	5	0	5	0,16
ɢ|qh [ɴɢ|qh]	voiced [|] + uvular aspirated stop	4	0	4	0,13
|q'	[|] with uvular ejective	18	1	17	0,59
|h	[|] with delayed aspiration	16	1	15	0,52
|n̥	[|] with voiceless nasal	5	0	5	0,16
|n	[|] with voiced nasal	63	2	61	2,05

Onset		Number of entries	Following vowel		% of onsets
Orth.	IPA		Front vowel	Back vowel	
ˀ|n	[|] with pre-glottalised nasal	36	3	33	1,17
|'	[|] with glottal stop	28	2	26	0,91
!	alveolar abrupt click [!]	132	0	132	4,29
!g	voiced [!]	80	2	78	2,60
!x	[!] + voiceless velar fricative	21	0	21	0,68
g!x	voiced [!] + voiceless velar fricative	9	0	9	0,29
!kx'	[!] + velar ejective	16	0	16	0,52
g!kx'	voiced [!] + velar ejective	4	0	4	0,13
!q	[!] + uvular stop	17	0	17	0,55
!ɢ	voiced [!] + uvular stop	35	0	35	1,14
!qh	[!] with aspirated stop	26	0	25	0,85
g!qh	voiced [!] with aspirated stop	9	0	9	0,29
ɢ!qh	voiced [!] + uvular aspirated stop	3	0	3	0,10
!q'	[!] with uvular ejective	13	0	13	0,42
!h	[!] with delayed aspiration	26	1	25	0,85
!n̥	[!] with voiceless nasal	11	0	11	0,36
!n	[!] with voiced nasal	115	0	115	3,74
ˀ!n	[!] with pre-glottalised nasal	39	0	39	1,27
!'	[!] with glottal stop	30	0	30	0,98
ǁ	lateral click with friction [ǁ]	117	0	117	3,80
ǁg	voiced [ǁ]	76	0	76	2,47
ǁx	[ǁ] + voiceless velar fricative	33	0	33	1,07
gǁx	voiced [ǁ] + voiceless velar fricative	14	0	14	0,46
ǁkx'	[ǁ] + velar ejective	18	0	18	0,59
gǁkx'	voiced [ǁ] + velar ejective	13	0	13	0,42
ǁq	[ǁ] + uvular stop	31	0	31	1,01
ǁɢ	voiced [ǁ] + uvular stop	29	0	29	0,94
ǁqh	[ǁ] with aspirated stop	40	0	40	1,30
gǁqh	voiced [ǁ] with aspirated stop	7	0	7	0,23
ɢǁqh	voiced [ǁ] + uvular aspirated stop	7	0	7	0,23
ǁq'	[ǁ] with uvular ejective	27	0	27	0,88
ǁh	[ǁ] with delayed aspiration	19	1	18	0,62
ǁn̥	[ǁ] with voiceless nasal	8	0	8	0,26
ǁn	[ǁ] with voiced nasal	92	0	92	2,99
ˀǁn	[ǁ] with pre-glottalised nasal	46	0	46	1,50
ǁ'	[ǁ] with glottal stop	37	1	36	1,20
ǂ	palatal abrupt click [ǂ]	84	7	77	2,73
ǂg	voiced [ǂ]	65	7	58	2,11
ǂx	[ǂ] + voiceless velar fricative	20	0	20	0,65
gǂx	voiced [ǂ] + voiceless velar fricative	10	0	10	0,33
ǂkx'	[ǂ] + velar ejective	9	0	9	0,29
gǂkx'	voiced [ǂ] + velar ejective	10	0	10	0,33

Onset		Number of entries	Following vowel		% of onsets
Orth.	**IPA**		**Front vowel**	**Back vowel**	
ɬq	[ɬ] + uvular stop	37	0	37	1,20
ɬɢ	voiced [ɬ] + uvular stop	42	1	41	1,37
ɬqh	[ɬ] with aspirated stop	41	1	41	1,33
gɬqh	voiced [ɬ] with aspirated stop	12	2	10	0,39
ɬq'	[ɬ] with uvular ejective	5	0	5	0,16
ɬh	[ɬ] with delayed aspiration	17	1	16	0,55
ɬn̥	[ɬ] with voiceless nasal	3	0	3	0,10
ɬn	[ɬ] with voiced nasal	49	0	49	1,59
ˀɬn	[ɬ] with pre-glottalised nasal	15	0	15	0,49
ɬ'	[ɬ] with glottal stop	43	3	40	1,40
p	voiceless labial stop	14	5	9	0,46
b	voiced labial stop	29	7	22	0,94
br		2	2	0	0,07
ph	aspirated labial stop	4	0	4	0,13
p'kx'	ejected labial stop + ejected velar affricate	1	0	1	0,03
t	voiceless dental stop	80	9	70	2,60
tr		4	2	2	0,13
d	voiced dental stop	42	5	37	1,37
dr		1	0	1	0,03
tx	dental stop + velar fricative	7	0	7	0,23
dtx	voiced dental stop + velar fricative	7	0	7	0,23
th	aspirated dental stop	23	4	19	0,75
dth	voiced aspirated dental stop	7	0	7	0,23
t'	ejected dental stop	3	0	3	0,10
t'kx'	ejected dental stop + ejected velar affricate	12	0	12	0,39
dt'kx'	ejected voiced dental stop + ejected velar affricate	7	0	7	0,23
ts	voiceless alveolar stop	31	0	31	1,01
dz	voiced alveolar stop	38	1	37	1,24
tsh	aspirated alveolar stop	28	3	25	0,91
dtsh	voiced aspirated alveolar stop	13	0	13	0,42
tshx	alveolar stop + velar fricative	16	0	16	0,52
dtshx	voiced alveolar stop + velar fricative	13	0	13	0,42
ts'	ejected alveolar stop	12	1	11	0,39
ts'kx'	ejected alveolar stop + ejected velar affricate	8	0	8	0,26
dts'kx'	ejected voiced alveolar stop + ejected velar affricate	6	0	6	0,20
k	voiceless velar stop	60	1	59	1,95
g	voiced velar stop	55	0	55	1,79
gr		1	1	0	0,03

Onset		Number of entries	Following vowel		% of onsets
Orth.	**IPA**		**Front vowel**	**Back vowel**	
kh	aspirated velar stop	11	1	10	0,36
gkh	voiced aspirated velar stop	2	0	2	0,07
kx'	ejected velar stop	21	0	21	0,68
gkx'	ejected voiced velar stop	8	0	8	0,26
k'	ejected velar stop	1	0	1	0,03
q	voiceless uvular stop	78	0	78	2,54
ɢ [ɴɢ]	voiced uvular stop	25	0	25	0,81
qh	aspirated uvular stop	22	0	22	0,72
ɢqh [ɴɢqh]	voiced aspirated uvular stop	2	0	2	0,07
q'	ejected uvular stop	9	0	9	0,29
f	labial fricative	4	0	4	0,13
s	alveolar fricative	77	23	54	2,50
x	velar fricative	32	0	32	1,04
h	glottal fricative	20	0	20	0,65
l	alveolar lateral approximant	10	2	8	0,33
m	voiced labial nasal	17	2	15	0,55
ˀm	pre-glottalised labial nasal	2	1	1	0,07
n	dental nasal	26	4	22	0,85
ˀn	pre-glottalised dental nasal	5	0	4	0,16
w		2	1	1	0,07
ˀV		21	4	17	0,68
TOTAL		**3076**	**122**	**2952**	

!Xóõ has laryngeal vowel phonation types that are prohibited from occurring with certain segments. Vowel phonation types are plain, nasalised, breathy, pharyngealised, and glottalised. The non-modal phonation types may combine, such as in the case of 'strident' vowels, which are both pharyngealised and breathy (Traill, 1994). In this dataset, the following patterns regarding the co-occurrence of consonants and non-modal vowels occur: any plosive that is aspirated, has glottalisation or a uvular fricative/ejective affricate accompaniment generally cannot be followed by a breathy, glottalised, pharyngealised or strident vowel. Only plain or nasal vowels follow these sounds[16]. A few exceptions are observed[17]. Regarding the restriction

[16] Nasalisation of vowels is considered to originate on the second mora and all other non-modal phonation types are restricted to the first mora, so nasalisation on the vowel immediately following a consonant is due to spreading (Traill, 1985).

[17] Exceptions are occasionally observed after: *g|x, g!x, g||x, g‡x, dtx, dtshx, kx', x, g|kx', ʘqh, |qh, ||qh, ‡qh, g‡qh, qh*. Rarely, these sounds can be followed by glottalised vowels. The sounds dtsh and tsh

of laryngeal vowel phonation types after fricatives, the uvular fricative *x* may occasionally be followed by a glottalised vowel but may not be followed by a breathy or pharyngeal vowel. In comparison, uvular plosives and plosives with a uvular stop component are frequently followed by these vowel types. And finally, *s* may not be followed by a breathy vowel, but is followed by glottal or pharyngeal vowels, and *h* can be followed by any kind of vowel.

The following O/E ratios are calculated if one assumes the following consonant sequences to be clusters: stops + *x*, stops + *kx'*, clicks + *q*, and clicks + *q'*. The second group includes egressive segments such as *t'kx'* and *ts'kx'* and supposes that the initial consonant in the sequence is a plain – not ejective – stop, premised upon the assumption that glottalization operates over the whole onset (Traill, 1985). O/E ratios calculated using *t'* and *ts'* as initial consonants yielded a higher output than that of the plain stops, as the ejective segments tend to occur less frequently.

Table 19. O/E ratios for stops with velar fricative in !Xóõ

Onset	ʘx	|x	!x	ǁx	ǂx	tx	tshx
S1	ʘ	|	!	ǁ	ǂ	t	ts
S2	x	x	x	x	x	x	x
Observed	2	17	21	33	20	7	16
Expected	0.14	0.79	1.37	1.22	0.87	0.83	0.32
O/E	14.79	21.50	15.29	27.11	22.89	8.41	49.61

Table 20. O/E ratios for stops with ejected velar affricate in !Xóõ

Onset	ʘkx'	|kx'	!kx'	ǁkx'	ǂkx'	t'kx'	ts'kx'
S1	ʘ	|	!	ǁ	ǂ	t	ts
S2	kx'	kx'	kx'	kx'	kx'	kx'	kx'
Observed	1	7	16	18	9	12	8
Expected	0.09	0.52	0.90	0.80	0.57	0.55	0.21
O/E	11.27	13.49	17.75	22.53	15.69	21.97	37.80

Table 21. O/E ratios for clicks with uvular stop in !Xóõ

Onset	ʘq	|q	!q	ǁq	ǂq
S1	ʘ	|	!	ǁ	ǂ
S2	q	q	q	q	q
Observed	5	15	17	31	37
Expected	0.33	1.93	3.35	2.97	2.13
O/E	15.17	7.78	5.08	10.45	17.37

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may infrequently be followed by other non-modal phonation types. Furthermore, preglottalised nasal segments can co-occur with vowels of various phonation types, so there may be some representational difference between glottalisation and preglottalization, or between nasal and oral segments.

Table 22. O/E ratios for clicks with ejected uvular stop in !Xóõ

Onset	ʘq’	ǀq’	!q’	ǁq’	ǂq’
S1	ʘ	ǀ	!	ǁ	ǂ
S2	q’	q’	q’	q’	q’
Observed	3	18	13	27	5
Expected	0.04	0.22	0.39	0.34	0.25
O/E	78.87	80.95	33.66	78.87	20.34

5.1.4 N|uu

Table 23. Frequency table for word onsets in N|uu (Sands & Jones, 2022)

Onset		**Number of entries**	**Following vocoid**			**% of onsets**
Orth.	**Description**		**Front vowel**	**Back vowel**	**Nasal**	
b	[b]	17	3	14	0	0,96
bl	[bl]	2	0	2	0	0,11
br	[br]	1	0	1	0	0,06
c'	[c']	2	0	2	0	0,11
c	[c]	25	3	22	0	1,42
ch	[cʰ]	1	0	1	0	0,06
cx	[t̪s̪χ]	8	0	8	0	0,45
d	[d]	5	3	2	0	0,28
dr	[dr]	2	0	2	0	0,11
dsyh	[d̪̊s̪ʱ]	9	9	0	0	0,51
f	[f]	3	1	2	0	0,17
fl	[fl]	1	0	1	0	0,06
g	[g]	18	4	14	0	1,02
gq	[ɢ̊]	3	0	3	0	0,17
g|	[ᶢǀ]	23	6	17	0	1,31
g|h	[ᶢ̥ǀʱ]	1	0	1	0	0,06
g|q	[ᶢǀq], [ɢ̊ǀq]	2	0	2	0	0,11
gǁ	[ᶢǁ]	17	0	17	0	0,96
g!	[ᶢ!]	41	0	41	0	2,33
g!q	[ᶢ!q], [ᶢ̥!q]	3	0	3	0	0,17
gǂ	[ᶢǂ]	16	3	13	0	0,91
h	[h], [ɦ]	29	3	23	3	1,65
j	[ɟ]	38	9	29	0	2,16
k	[k]	89	23	66	0	5,05
kh	[kʰ]	9	1	8	0	0,51
kl	[kl]	1	0	1	0	0,06
kq'	[q']	1	0	1	0	0,06
kq	[q]	8	0	8	0	0,45
kr	[kr]	1	0	1	0	0,06
kx'	[kχ']	32	0	32	0	1,82
ky	[kʲ]	1	1	0	0	0,06
l	[l]	7	4	3	0	0,40

Onset		Number of entries	Following vocoid			% of onsets
Orth.	Description		Front vowel	Back vowel	Nasal	
m	[m]	15	3	12	0	0,85
mʘ	[ᵑʘ]	2	0	2	0	0,11
n	[n]	6	2	4	0	0,34
ng	[ŋ]	4	0	0	0	0,23
ny	[ɲ]	4	1	3	0	0,23
n|'h	[ᵑ|ʰ]	9	1	8	0	0,51
n|	[ᵑ|]	32	3	28	1	1,82
n‖'h	[ᵑ‖ʰ]	3	0	3	0	0,17
n‖'	[ᵑ‖ˀ]	2	0	0	2	0,11
n‖	[ᵑ‖]	32	0	25	7	1,82
n!'h	[ᵑ!ʰ]	2	0	2	0	0,11
n!	[ᵑ!]	36	0	36	0	2,04
nǂ'h	[ᵑǂʰ]	4	0	4	0	0,23
nǂ	[ᵑǂ]	32	5	27	0	1,82
p	[p]	12	4	8	0	0,68
ph	[pʰ]	2	1	1	0	0,11
pl	[pl]	1	0	1	0	0,06
pr	[pr]	3	2	1	0	0,17
r	[r]	2	0	2	0	0,11
s	[s]	42	15	27	0	2,38
sk	[sk]	2	0	2	0	0,11
sl	[sl]	1	0	1	0	0,06
st	[st]	2	0	2	0	0,11
t	[t]	8	4	4	0	0,45
tr	[tr]	3	2	1	0	0,17
ts'	[ts']	29	8	21	0	1,65
ts	[ts]	9	2	7	0	0,51
tsh	[tsʰ]	3	0	3	0	0,17
tsy'	[t̠s̠ˀ]	2	0	2	0	0,11
tsyh	[t̠s̠ʰ]	5	1	4	0	0,28
tsy	[t̠s̠]	9	1	8	0	0,51
x	[χ]	28	1	27	0	1,59
xr	[χr]	1	1	0	0	0,06
z	[z]	2	1	1	0	0,11
ʘ'	[ᵑ̊ʘˀ]	3	0	3	0	0,17
ʘ	[ʘ]	18	0	18	0	1,02
ʘq	[ʘq]	3	0	3	0	0,17
ʘx'	[ʘχ']	1	0	1	0	0,06
ʘx	[ʘχ]	2	0	2	0	0,11
|'	[ᵑ̊|ˀ]	41	6	35	0	2,33
|'h	[ᵑ̊|ʰ]	29	0	29	0	1,65
|	[|]	73	26	47	0	4,14
|h	[|ʰ]	24	8	16	0	1,36

Onset		Number of entries	Following vocoid			% of onsets
Orth.	Description		Front vowel	Back vowel	Nasal	
ǀq'	[ǀq'] ~ [ǀχ']	1	0	1	0	0,06
ǀq	[ǀq]	17	2	15	0	0,96
ǀqh	[ǀqʰ]	20	3	17	0	1,14
ǀx'	[ǀχ']	38	3	35	0	2,16
ǀx	[ǀχ]	5	0	5	0	0,28
ǁ'	[ᵑ̊ǁˀ]	43	1	39	3	2,44
ǁ'h	[ᵑ̊ǁʰ]	12	0	12	0	0,68
ǁ	[ǁ]	63	0	63	0	3,58
ǁh	[ǁʰ]	31	0	31	0	1,76
ǁq	[ǁq]	14	2	12	0	0,79
ǁqh	[ǁqʰ]	13	0	13	0	0,74
ǁx'	[ǁχ']	30	0	30	0	1,70
ǁx	[ǁχ]	24	0	24	0	1,36
ǃ'	[ᵑ̊ǃˀ]	46	0	46	0	2,61
ǃ'h	[ᵑ̊ǃʰ]	20	0	20	0	1,14
ǃ	[ǃ]	93	0	93	0	5,28
ǃh	[ǃʰ]	23	0	23	0	1,31
ǃq	[ǃq]	23	1	22	0	1,31
ǃqh	[ǃqʰ]	15	1	14	0	0,85
ǃx'	[ǃχ']	17	0	17	0	0,96
ǃx	[ǃχ]	19	0	19	0	1,08
ǂ'	[ᵑ̊ǂˀ]	36	10	26	0	2,04
ǂ'h	[ᵑ̊ǂʰ]	18	3	15	0	1,02
ǂ	[ǂ]	61	4	57	0	3,46
ǂh	[ǂʰ]	38	4	34	0	2,16
ǂq	[ǂq]	15	1	14	0	0,85
ǂqh	[ǂqʰ]	19	5	14	0	1,08
ǂx'	[ǂχ']	19	0	19	0	1,08
ǂx	[ǂχ]	30	0	30	0	1,70
TOTAL		**1762**	**211**	**1531**	**16**	

Vowels in Nǀuu may be modal, nasal, epiglottal/pharyngeal, and nasal epiglottal/pharyngeal (Miller, Brugman, et al., 2007; Sands & Jones, 2022). There seems to be a partially active co-occurrence restriction between certain consonants and the epiglottal/pharyngeal phonation type. Epiglottalised vowels do not occur after [kχ’] or [χ] but do occur after some aspirated or glottalised segments, such as [c’], [ts’] or [t̪s̪ʰ]. Epiglottalised vowels are also observed after clicks with a dorsal fricative/ejective release. Uvular stops and sounds with a uvular stop release allow epiglottalised vowels to follow them.

O/E ratios for clicks with a uvular fricative and a uvular ejective were calculated, assuming that these sounds are clusters of stop + *x* and stop + *kx'*, respectively.

Table 24. O/E ratios for stops with a uvular fricative in N|uu

Onset	ʘx	|x	!x	ǁx	ǂx
S1	ʘ	|	!	ǁ	ǂ
S2	x	x	x	x	x
Observed	2	5	19	24	30
Expected	0.29	1.16	1.48	1.00	0.97
O/E	6.99	4.31	12.86	23.97	30.95

Table 25. O/E ratios for clicks with a uvular ejective in N|uu

Onset	ʘx'	|x'	!x'	ǁx'	ǂx'
S1	ʘ	|	!	ǁ	ǂ
S2	kx'	kx'	kx'	kx'	kx'
Observed	1	38	17	30	19
Expected	0.33	1.33	1.69	1.14	1.11
O/E	3.06	28.66	10.07	26.22	17.15

Table 26. O/E ratios for clicks with a uvular stop in N|uu

Onset	ʘq	|q	!q	ǁq	ǂq
S1	ʘ	|	!	ǁ	ǂ
S2	q	q	q	q	q
Observed	3	17	23	14	15
Expected	0.08	0.33	0.42	0.29	0.28
O/E	36.71	51.29	54.47	48.94	54.16

5.1.5 Ju|'hoan

Table 27. Frequency table of word onsets for Ju|'hoan (Dickens, 1994)

Onset		**Number of entries**	**Following vowel**		**% of onsets**
Orth.	**Description**		**Front vowel**	**Back vowel**	
b	[b]	55	7	48	1,50
bh	[bpʰ]	3	2	1	0,08
bl		1	0	1	0,03
br		2	2	0	0,05
c	[ʃ]	54	9	45	1,48
d	[d]	90	11	79	2,46
dc	[dtʃ']	9	1	8	0,25
dch	[dʃʰ]	8	4	4	0,22
dh	[dtʰ]	11	1	10	0,30
dj		1	1	0	0,03
djx	[dʒx]	12	0	12	0,33
dr		1	0	1	0,03
ds	[dts']	4	0	4	0,11
dsh	[dtsʰ]	9	5	4	0,25

Onset		Number of entries	Following vowel		% of onsets
Orth.	**Description**		**Front vowel**	**Back vowel**	
dx		6	0	6	0,16
dzx	[dzx]	2	0	2	0,05
f	[f]	5	0	5	0,14
fl		1	0	1	0,03
fr		1	0	1	0,03
g	[g]	79	4	75	2,16
gh	[gkʰ]	6	0	6	0,16
gr		1	1	0	0,03
g|	[|g]	69	0	69	1,89
g|h	[g|kʰ]	7	0	7	0,19
g|k	[g|kx']	5	0	5	0,14
g|x	[g|x]	8	0	8	0,22
gǂ	[ǂg]	58	0	58	1,59
gǂh	[gǂkʰ]	10	0	10	0,27
gǂk	[gǂkx']	17	0	17	0,47
gǂx	[gǂx]	9	0	9	0,25
g!	[!g]	164	0	164	4,49
g!h	[g!kʰ]	5	0	5	0,14
g!k	[g!kx']	14	0	14	0,38
g!x	[g!x]	14	0	14	0,38
g‖	[‖g]	69	0	69	1,89
g‖h	[g‖kʰ]	0	0	0	0,00
g‖k	[g‖kx']	4	0	4	0,11
g‖x	[g‖x]	6	0	6	0,16
h	[ɦ], or shows aspiration or breathiness	51	9	42	1,40
j	[ʒ]	33	2	31	0,90
k	[k]	165	10	155	4,51
kh	[kʰ]	44	0	44	1,20
kl		3	0	3	0,08
kr		1	0	1	0,03
kx	[kx']	49	0	49	1,34
kxh		1	0	1	0,03
l	[l]	2	1	1	0,05
m	[m]	35	2	33	0,96
n	[n], or shows preceding nasalisation	41	7	34	1,12
n|	[|ŋ]	96	4	92	2,63
n|h	[ŋ|ʰ]	14	0	14	0,38
nǂ	[ǂŋ]	96	0	96	2,63
nǂh	[ŋǂʰ]	21	0	21	0,57
n!	[!ŋ]	142	1	141	3,89
n!h	[ŋ!ʰ]	42	0	42	1,15

Onset		Number of entries	Following vowel		% of onsets
Orth.	Description		Front vowel	Back vowel	
nǁ	[ǁŋ]	72	0	72	1,97
nǁh	[ŋǁʰ]	20	0	20	0,55
p	[p]	31	9	22	0,85
ph	[pʰ]	5	1	4	0,14
pl		2	0	2	0,05
r	[r]	6	1	5	0,16
s	[s]	52	10	42	1,42
sk		2	1	1	0,05
sm		3	0	3	0,08
sp		3	2	1	0,08
st		3	0	3	0,08
str		1	0	1	0,03
sw		2	0	2	0,05
t	[t]	121	17	104	3,31
tc	[tʃ]	47	10	37	1,29
tch	[tʃʰ]	23	15	8	0,63
tcx	[tʃx]	9	0	9	0,25
th	[tʰ]	20	0	20	0,55
tj	[tʃ']	15	2	13	0,41
ts	[ts]	40	6	34	1,09
tsh	[tsʰ]	16	9	7	0,44
tsx	[tsx]	13	0	13	0,36
tx	[tx]	15	0	15	0,41
tz	[ts']	40	13	27	1,09
tk	[tkx']	8	0	8	0,22
v	[v]	2	0	2	0,05
w	[w]	12	3	9	0,33
x	[x]	47	0	47	1,29
xl		1	0	1	0,03
y	[j]	6	2	4	0,16
z	[z]	63	8	55	1,72
ǀ	[ǀ]	95	0	95	2,60
ǀh	[ǀkʰ]	19	0	19	0,52
ǀk	[ǀkx']	30	0	30	0,82
ǀx	[ǀx]	36	0	36	0,98
ǀ'	[ǀʔ]	51	0	51	1,40
ǀ'h	[ǀʰ]	27	0	27	0,74
ǂ	[ǂ]	109	0	109	2,98
ǂh	[ǂkʰ]	22	0	22	0,60
ǂk	[ǂkx']	17	0	17	0,47
ǂx	[ǂx]	47	0	47	1,29
ǂ'	[ǂʔ]	59	0	59	1,61
ǂ'h	[ǂʰ]	43	0	43	1,18

Onset		Number of entries	Following vowel		% of onsets
Orth.	Description		Front vowel	Back vowel	
!	[!]	188	0	188	5,14
!h	[!kʰ]	36	0	36	0,98
!k	[!kx']	35	0	35	0,96
!x	[!x]	65	0	65	1,78
!'	[!ʔ]	76	0	76	2,08
!'h	[!ʰ]	47	0	47	1,29
ǁ	[ǁ]	101	0	101	2,76
ǁh	[ǁkʰ]	14	0	14	0,38
ǁk	[ǁkx']	28	0	28	0,77
ǁx	[ǁx]	50	0	50	1,37
ǁ'	[ǁʔ]	67	0	67	1,83
ǁ'h	[ǁʰ]	37	0	37	1,01
TOTAL		**3655**	**193**	**3462**	

It is vital to note that Dickens (1994) recorded [əi] and [i] as *ai*, which affects the data significantly.

The following O/E ratios reflect the co-occurrence of stops + *x* and stops + *kx'* if these sound sequences are considered clusters. The latter is represented in the orthography as a stop + *k* but is described as being released with an ejective velar affricate.

Table 28. O/E ratios for stops with velar fricative in Ju|'hoan

Onset	|x	!x	ǁx	ǂx	tx	tsx	tcx
S1	|	!	ǁ	ǂ	t	ts	tc
S2	x	x	x	x	x	x	x
Observed	36	65	50	47	15	13	9
Expected	1.22	2.32	1.30	1.40	1.56	0.51	0.60
O/E	29.47	26.89	38.50	33.53	9.64	25.27	14.89

Table 29. O/E ratios for stops with an ejected velar affricate in Ju|'hoan

Onset	|k	!k	ǁk	ǂk	tk
S1	|	!	ǁ	ǂ	t
S2	kx’	kx’	kx’	kx’	kx’
Observed	30	35	28	17	8
Expected	1.27	2.52	1.35	1.46	1.62
O/E	23.56	13.89	20.68	11.63	4.93

O/E ratios were also run to assess the claim that delayed aspirated/voiceless nasal aspirated clicks may be clusters of plain click + *h*. Dickens (1994) describes this as long aspiration or velar-inaudible aspiration, as opposed to short or velar-audible aspiration.

Table 30. O/E ratios for clicks with delayed aspiration in Ju|'hoan

Onset	|'h	!'h	ǁ'h	ǂ'h
S1	|	!	ǁ	ǂ
S2	h	h	h	h
Observed	27	47	37	43
Expected	1.33	2.62	1.41	1.52
O/E	20.37	17.92	26.25	28.27

5.1.6 Ekoka !Xun

Table 31. Frequency table for word onsets in Ekoka !Xun (König & Heine, 2008)

Onset		**Number of entries**	**Following vocoid**			**% of onsets**
Orth.	**Description**		**Front vowel**	**Back vowel**	**Nasal**	
b	voiced labial stop	25	6	19	0	0,87
bh	voiced labial stop + aspiration	5	0	5	0	0,17
c	plain palatal fricative	106	21	76	9	3,70
d	voiced alveolar stop	62	10	52	0	2,16
dch	voiced palatal stop + aspiration	2	0	2	0	0,07
dc		3	1	0	2	0,10
dcx		2	0	2	0	0,07
dcx'	voiced palatal stop + /x'/ (cluster)	12	0	12	0	0,42
dc'	voiced palatal stop + glottal	3	0	1	2	0,10
dh	voiced alveolar stop + aspiration	6	0	6	0	0,21
dj	voiced palatal stop [dʒ]	66	8	56	2	2,30
dth	voiced alveolar fortis stop	3	0	3	0	0,10
dx	voiced alveolar stop + /x/ (cluster)	3	0	3	0	0,10
g	voiced velar stop	65	6	59	0	2,27
gh	voiced velar stop + aspiration	14	0	14	0	0,49
gkh	voiced velar fortis stop	7	0	7	0	0,24
gkx'		1	0	1	0	0,03
g|	voiced dental click	39	8	30	1	1,36
g|h	voiced dental click + aspiration (cluster)	1	0	1	0	0,03
g|x	voiced dental click + /x/ (cluster)	4	0	4	0	0,14
g|x'	voiced dental click + /x'/ (cluster)	8	0	8	0	0,28
g!	voiced alveolar click	69	0	67	2	2,41
g!h	voiced alveolar click + aspiration (cluster)	4	0	4	0	0,14
g!x	voiced alveolar click + /x/ (cluster)	7	0	7	0	0,24
g!x'	voiced alveolar click + /x'/ (cluster)	8	0	8	0	0,28
g!!	voiced retroflex click	36	7	29	0	1,26
g!!h	voiced retroflex click + aspiration (cluster)	5	2	3	0	0,17
g!!x	voiced retroflex click + /x/ (cluster)	4	0	4	0	0,14
g!!x'	voiced retroflex click + /x'/ (cluster)	5	0	5	0	0,17
gǁ	voiced lateral click	91	0	90	1	3,18

Onset		Number of entries	Following vocoid			% of onsets
Orth.	**Description**		**Front vowel**	**Back vowel**	**Nasal**	
g‖h	voiced lateral click + aspiration (cluster)	2	0	2	0	0,07
g‖x	voiced lateral click + /x/ (cluster)	9	0	9	0	0,31
g‖x'	voiced lateral click + /x'/ (cluster)	16	0	16	0	0,56
h	plain glottal fricative [ɦ]	33	5	18	10	1,15
k	plain velar stop	111	6	105	0	3,88
kh	plain velar stop + aspiration	40	0	40	0	1,40
khw		4	3	1	0	0,14
kw		13	5	8	0	0,45
kx'	plain velar stop + glottal	38	0	38	0	1,33
l	plain alveolar non-nasal sonorant	7	3	4	0	0,24
m	plain labial nasal	17	4	13	0	0,59
n	plain alveolar nasal	18	2	16	0	0,63
ˀn	glottal + alveolar nasal (cluster)	3	0	3	0	0,10
ndj		1	0	1	0	0,03
nd	alveolar nasal + stop (cluster)	3	0	3	0	0,10
ŋg	velar nasal + stop (cluster)	3	0	3	0	0,10
nh	alveolar nasal + aspiration (cluster)	3	0	3	0	0,10
nj		1	0	1	0	0,03
n|	nasal dental click	65	6	57	2	2,27
ˀn|	glottal + nasal dental click (cluster)	18	7	11	0	0,63
n|h	nasal dental click + aspiration (cluster)	5	1	4	0	0,17
n!	nasal alveolar click	99	1	97	1	3,46
ˀn!	glottal + nasal alveolar click (cluster)	8	0	8	0	0,28
n!h	nasal alveolar click + aspiration (cluster)	12	0	12	0	0,42
n!!	nasal retroflex click	74	4	69	1	2,58
ˀn!!	glottal + nasal retroflex click (cluster)	8	3	5	0	0,28
n!!h	nasal retroflex click + aspiration (cluster)	5	0	4	1	0,17
n‖	nasal lateral click	95	2	90	3	3,32
ˀn‖	glottal + nasal lateral click (cluster)	8	0	8	0	0,28
n‖h	nasal lateral click + aspiration (cluster)	22	0	22	0	0,77
p	plain labial stop	8	3	5	0	0,28
ph	plain labial stop + aspiration	4	0	4	0	0,14
t	plain alveolar stop	90	16	74	0	3,14
tc	plain palatal stop [tʃ]	91	25	64	2	3,18
tch	plain palatal stop + aspiration	3	0	3	0	0,10
tcx	plain palatal stop + /x/ (cluster)	16	0	16	0	0,56
tcx'		6	0	6	0	0,21
tc'	plain palatal stop + glottal	25	5	18	2	0,87

Onset		Number of entries	Following vocoid			% of onsets
Orth.	**Description**		**Front vowel**	**Back vowel**	**Nasal**	
th	plain alveolar stop + aspiration	23	1	22	0	0,80
tk	[tk] ~ [tx] (cluster)	1	0	1	0	0,03
tx	plain alveolar stop + /x/ (cluster)	10	0	10	0	0,35
tx'		2	0	2	0	0,07
w	plain labial non-nasal sonorant	10	2	8	0	0,35
x	plain velar fricative	48	0	48	0	1,68
y	plain palatal non-nasal sonorant	10	6	4	0	0,35
|	plain dental click	75	7	66	2	2,62
|h	plain dental click + aspiration (cluster)	17	1	14	2	0,59
|x	plain dental click + /x/ (cluster)	26	0	25	1	0,91
|x'	plain dental click + /x'/ (cluster)	27	0	27	0	0,94
|'	plain dental click + glottal	40	5	34	1	1,40
|'h	plain dental click + aspiration	31	2	27	2	1,08
!	plain alveolar click	141	1	136	4	4,92
!h	plain alveolar click + aspiration (cluster)	42	0	40	2	1,47
!x	plain alveolar click + /x/ (cluster)	36	0	36	0	1,26
!x'	plain alveolar click + /x'/ (cluster)	17	0	17	0	0,59
!'	plain alveolar click + glottal	55	0	53	2	1,92
!'h	plain alveolar click + aspiration	32	0	29	3	1,12
!!	plain retroflex click[18]	85	15	68	2	2,97
!!h	plain retroflex click + aspiration (cluster)	27	2	21	4	0,94
!!x	plain retroflex click + /x/ (cluster)	28	0	27	1	0,98
!!x'	plain retroflex click + /x'/ (cluster)	11	0	11	0	0,38
!!'	plain retroflex click + glottal	38	3	30	5	1,33
!!'h	plain retroflex click + aspiration	44	5	32	7	1,54
‖	plain lateral click	149	1	143	5	5,20
‖h	plain lateral click + aspiration (cluster)	43	2	41	0	1,50
‖x	plain lateral click + /x/ (cluster)	39	0	39	0	1,36
‖x'	plain lateral click + /x'/ (cluster)	23	0	22	1	0,80
‖'	plain lateral click + glottal	41	0	37	4	1,43
‖'h	plain lateral click + aspiration	43	0	38	5	1,50
TOTAL		**2864**	**223**	**2547**	**94**	

[18] This sound is now considered a fricated palatal click [ǂ] (Sands, 2020).

Various marginally-occurring sounds – *ddj*, *g|'h*, *t'h*, *n|'h*, *'n!h*, *n!'*, *n!'h*, *'n!!h*, *n!!'h*, and *n‖'h* – were excluded from the frequency count as the orthography was not clear enough to interpret the phonetic content of the symbols.

Onsets that are glottalised, aspirated, or have a dorsal fricative accompaniment may not be followed by vowels with laryngeal phonation types (breathy or pharyngeal). There are remarkably few exceptions to the Guttural OCP in the Ekoka !Xun dataset, apart from preglottalised nasals, which seem not to be included in this constraint.

O/E ratios were calculated assuming that stops + *x* and stops + *x'* are clusters.

Table 32. O/E ratios for stops with velar fricative in Ekoka !Xun

Onset	|x	!x	‖x	!!x	tx	tcx	dcx
S1	|	!	‖	!!	t	tc	dc
S2	x	x	x	x	x	x	x
Observed	26	36	39	28	10	16	2
Expected	1.26	2.36	2.50	1.42	1.51	1.53	0.05
O/E	20.68	15.23	15.62	19.65	6.63	10.49	39.78

Table 33. O/E ratios for stops with ejected velar affricate in Ekoka !Xun

Onset	|x'	!x'	‖x'	!!x'	tx'	tcx'
S1	|	!	‖	!!	t	tc
S2	kx'	kx'	kx'	kx'	kx'	kx'
Observed	27	17	23	11	2	6
Expected	0.10	1.87	1.98	1.13	1.19	1.21
O/E	27.13	9.09	11.63	9.75	1.67	4.97

5.2 Onset consonant inventories

The frequency tables above show the onsets listed in each dictionary. The information presented in these frequency tables is vital to an examination of the phonological patterns of the languages but a formal analysis requires further phonetic and phonological information about the onsets themselves. Thus, this section includes an onset consonant inventory that I have compiled for each language, as well as the phonetic/phonological information that led me to make such representational choices. Phonological information that is pertinent for the discussion of these languages is also included. The focus of this thesis is consonant sequences that may be clusters or complex segments, so relevant sounds are discussed below. Other sounds that are less controversial are included without comment in the onset consonant inventories but are commented upon if the orthography of the source dictionary has been changed.

In the onset consonant inventory tables, consonants/consonant sequences marked with an asterisk are marginal, occurring as an onset in less than 0.5% of the entries. Sounds that occur only in loanwords or are considered to be foreign phonemes are excluded from the tables. Furthermore, sounds that occur only in one or two ideophones or place names are excluded from the inventory tables. Syllabic nasals are also omitted. The sounds in the onset inventories are represented as neutrally as possible and do not yet cleave to a cluster or unit analysis. In the following sections, sounds or words in italics are in the original dictionary orthography. I also include a brief description of vowels and their phonation types where relevant as this information is pertinent to my discussion.

Where I have changed the representation of sounds, the alveolar click is used to represent changes made to any click unless otherwise specified. I generally follow Sands (2020)'s representations for sounds in KBA languages.

5.2.1 Khoekhoegowab

Table 34. Inventory of Khoekhoegowab word-initial onsets

KHOEKHOEGOWAB onsets		Bilabial	Dental	Alveolar		Palatal	Velar	Glottal
				CENTRAL	LATERAL			
CLICKS	Plain		ǀ	ǃ	ǁ	ǂ		
	Aspirated / affricated		ǀxʰ	ǃxʰ	ǁxʰ	ǂxʰ		
	Glottalised		ᵑ̊ǀˀ	ᵑ̊ǃˀ	ᵑ̊ǁˀ	ᵑ̊ǂˀ		
	Nasal		ᵑǀ	ᵑǃ	ᵑǁ	ᵑǂ		
	Voiceless nasal aspirated		ᵑ̊ǀʰ	ᵑ̊ǃʰ	ᵑ̊ǁʰ	ᵑ̊ǂʰ		
STOPS	Plain	p	t				k	ʔ
	Aspirated / affricated		tsʰ				kxʰ	
FRICATIVES				s			x	h
NASALS		m	n					
LIQUIDS				r				

Table 35. Altered symbols for sounds in Khoekhoegowab

Original Orth.	My symbol	Reason for change
	ʔ	Included as a phoneme following Brugman (2009) and Vossen (2013).
kh	kxʰ	Can be realised as [kʰ] or [kx]. Described by Beach (1938) as a 'strongly aspirated affricate'. Haacke (Vossen, 2013) finds [kʰ] to be the more ubiquitous form.
ts	tsʰ	Brugman (2009) describes this as 'consistently affricated' and usually aspirated. Khoekhoegowab *ts* has two environmentally-conditioned

		allophones in !Ora: [ts] and [t^{h}] (Vossen, 2013). I use [ts^{h}] to represent both !Ora allophones.
!g	!	This click is voiceless, and Haacke and Eiseb (2002)'s orthography may be misleading.
!	$^{ŋ̊}!^{ʔ}$	This is a glottalised click. Voiceless nasal pulmonic airflow observed by Beach (1938) and Brugman (2009) is indicated by the voiceless nasal superscript.
!h	$^{ŋ̊}!^{h}$	Clicks with delayed aspiration have the same nasal venting observed for glottalised clicks by Beach (1938) and Brugman (2009).
!n	$^{ŋ}!$	Nasality is indicated with a velar nasal superscript (Sands, 2020)
!kh	$!x^{h}$	Beach (1938)'s click with a 'strong velar affricate efflux'. Described by Haacke and Eiseb (2002, p. v) as a click "followed by a voiceless velar fricative or affricate", [$!x^{h}$ ~ !kx]. Sands (2020) describes it as a uvular fricated click, [!͡χ], and Brugman (2009) describes it as having weak affrication that is phonetically between affrication and aspiration. Ladefoged and Traill (1994) represent this sound as an aspirated click rather than a click with a velar affricate. I represent it as [$!x^{h}$] to retain both phonetic realisations. This sound seems to correspond to both aspirated clicks and clicks with dorsal affrication in some assumed Khwe cognates[19].

The lateral liquid [l] is not included in the table above as it is regarded not as a phoneme but as an allophone of [n] in some Damara dialects (Haacke & Eiseb, 2002; Vossen, 2013). The central liquid occurs only in pronouns and some grammatical particles, and all other occurrence of this onset occur in loanwords.

[19] Examples of this correspondence include the following word-pairs, where the Khoekhoegowab form is given first and then the Khwe form. All words are presented in the original dictionary orthography (except for nasalization in Khoekhoegowab, which I represent with a tilde instead of a circumflex). The Khoekhoegowab aspirated/affricated clicks correspond to Khwe aspirated clicks in the word pairs *ǀkhúù* - *ǀhuúví*, meaning 'draw out, extract (such as tooth)' and *ǁkhã́ṹ* - *ǁhùú,* meaning 'rob, take away', but correspond to Khwe clicks with dorsal frication in the word pairs, *ǀkhã́ḿ* - *ǀxaḿ*, meaning 'urinate', and *ǁkhã́ó* - *ǁxáó*, meaning 'scrape'.

5.2.2 Khwe

Table 36. Inventory of Khwe word-initial onsets

KHWE onsets			Bilabial	Dental	Alveolar		Postalveolar / Palatal	Velar	Uvular	Glottal
					CENTRAL	LATERAL				
CLICKS	Plain	Voiceless		ǀ	ǃ	ǁ	ǂ			
		Voiced		^{g}ǀ		^{g}ǁ	^{g}ǂ			
	Aspirated	Voiceless		ǀ^{h}	ǃ^{h}*	ǁ^{h}	ǂ^{h}			
	Glottalised	Voiceless		ǀ^{ʔ}	ǃ^{ʔ}*	ǁ^{ʔ}	ǂ^{ʔ}			
	With dorsal fricative	Voiceless		ǀx		ǁx	ǂx			
	With glottalised dorsal affricate	Voiceless		ǀkx'		ǁkx'	ǂkx'			
	With uvular stop	Voiceless		ǀq	ǃq*	ǁq	ǂq			
	Nasal	Plain		^{ŋ}ǀ		^{ŋ}ǁ*	^{ŋ}ǂ			
		Prenasalised		^{ŋg}ǀ		^{ŋg}ǁ	^{ŋg}ǂ			
STOPS	Plain	Voiceless	p		t		tʃ	k	q	ʔ
		Voiced	b		d		dʒ	g		
	Aspirated	Voiceless	p^{h}		t^{h}			k^{h}		
	Glottalised	Voiceless			t'*		tʃ'	kx'		
	With dorsal fricative	Voiceless			tx		tʃx			
	Prenasalised	Voiced						ŋg		
	Palatalised	Voiceless						k^{j}		
		Voiceless aspirated						k^{hj}		
		Voiced						g^{j}		
		Prenasalised						ŋg^{j}		
FRICATIVES							ʃ	x		h
NASALS			m		n		ɲ*	ŋ*		
APPROXIMANTS							j	w		

The following table shows my changes to the symbols used to represent onsets in Khwe. Instead of the alveolar click, the dental click is used to represent any click in this table as the alveolar click series has been reduced through click loss.

Table 37. Altered symbols for sounds in Khwe

Original Orth.	**My symbol**	**Reason for change**
	ʔ	Considered to be a phoneme by Fehn (2019) and Vossen (2013), and Fehn notes that it also occurs in words that have lost a glottalised alveolar click. Not included in frequency counts or O/E ratios as it was not explicitly marked in the dictionary.
c	ʃ	Varies dialectally between alveolar, post-alveolar fricative, and palatal (Kilian-Hatz, 2003). Entries beginning with [s] are not recorded, so I use [ʃ].
tc	tʃ	Extrapolation from the description of the sound above.
dj	dʒ	This affricate may vary dialectally between an alveolar and post-alveolar place of production (Fehn, 2019).
ky	k^{j}	Palatalized egressives or velar nasals occur as a result of click loss of the alveolar click series (Fehn, 2019). [ŋg] also occurs in Bantu loanwords.
khy	k^{hj}	
gy	g^{j}	
ngy	ŋg^{j}	
ng	ŋg	

ny	ɲ	
kx	kx'	Kilian-Hatz (2003) describes this sound as a ‘postvelar ejective’. Fehn (2019) refer to this sound as velar, and Fehn considers it to be underlyingly /k’/. I represent the sound as [kx’].
ǀ’	$ǀ^{ʔ}$	This click is glottalised, not ejective. Nasal venting is not explicitly recorded so is not included.
ǀh	$ǀ^{h}$	This is an aspirated click. Its representation follows Sands (2020) and Fehn (2019).
ǀg	$^{g}ǀ$	I follow Sands (2020) in representing voiced clicks with a superscript velar stop.
ǀn	$^{ŋ}ǀ$	The nasal click is also represented with a superscript velar nasal.
nǀg	$^{ŋg}ǀ$	The prenasalised click is represented as such, following Sands (2020).

Contra Fehn (2019), I include $[p^h]$ in my onset consonant inventory, as the sound is not – strictly speaking – marginal, occurring in 0.52% of onsets. Vossen (1997) also includes this sound in his consonant inventory of Khwe, but remarks that it may be a borrowed phoneme as $[p^h]$ is not an attested phoneme in other Khoe languages.

Khwe seems to have been deeply influenced by surrounding Bantu languages. Many loanwords are marked in the Khwe dictionary. Fehn (2018) considers the onsets *mb*, *nd*, *ng*, and *l* to be borrowings in other related varieties of Kalahari Khoe, so these sounds are not included in the consonant inventory. Furthermore, *f* and *v* occur peripherally, but are not considered to be part of the native Khwe inventory (Vossen, 1997) and so are excluded from the inventory. The liquid *r* occurs only in grammatical particles, so is excluded from the onset inventory.

There are several onsets that are sequences of consonants plus *w.* I interpret these as borrowings from Bantu languages or cases of vowel reduction, where a high back vowel has been reduced to a glide before a front vowel. Neither Fehn (2018) nor Vossen (2013) include these sounds in their consonant inventory, so I follow them in omitting them from my onset inventory.

Clicks + *q* are considered to have a voiceless uvular stop accompaniment (Kilian-Hatz, 2003; Vossen, 2013). The clicks + *x* and clicks + *x’* are considered to have velar fricative and velar ejective affricate accompaniments, respectively. Fehn (2019) considers the ejective affricate click accompaniment to be [qx’] or [k’], depending on dialectal variation, but proposes that the underlying representation of the accompaniment is /k’/. For the sake of consistency between egressive and ingressive inventories, I represent this accompaniment as [kx’]. I do, however, refer to phonemic [kx’], and [x] and [kx’] accompaniments as ‘dorsal’ rather than velar, as there seems to be some uncertainty as to whether these sounds are velar or post-velar.

5.2.3 !Xóõ

Table 38. Inventory of !Xóõ word-initial onsets

<table>
<tr><th colspan="3" rowspan="2">!XÓÕ onsets</th><th rowspan="2">Bilabial</th><th rowspan="2">Dental</th><th colspan="2">Post-Dental/Alveolar</th><th rowspan="2">Palatal</th><th rowspan="2">Velar</th><th rowspan="2">Uvular-Pharyngeal</th><th rowspan="2">Glottal</th></tr>
<tr><th>CENTRAL</th><th>LATERAL</th></tr>
<tr><td rowspan="24">CLICKS</td><td rowspan="2">Plain</td><td>Voiceless</td><td>ʘ*</td><td>|</td><td>!</td><td>‖</td><td>ǂ</td><td></td><td></td><td></td></tr>
<tr><td>Voiced</td><td>ᶢʘ*</td><td>ᶢ|</td><td>ᶢ!</td><td>ᶢ‖</td><td>ᶢǂ</td><td></td><td></td><td></td></tr>
<tr><td>Glottalised</td><td>Voiceless</td><td>ᵑ̊ʘˀ</td><td>ᵑ̊|ˀ</td><td>ᵑ̊!ˀ</td><td>ᵑ̊‖ˀ</td><td>ᵑ̊ǂˀ</td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">With uvular fricative</td><td>Voiceless</td><td>ʘχ*</td><td>|χ</td><td>!χ</td><td>‖χ</td><td>ǂχ</td><td></td><td></td><td></td></tr>
<tr><td>(Pre)Voiced</td><td>ᶢʘχ*</td><td>ᶢ|χ*</td><td>ᶢ!χ*</td><td>ᶢ‖χ*</td><td>ᶢǂχ*</td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">With glottalised uvular affricate</td><td>Voiceless</td><td>ʘqχ’*</td><td>|qχ’*</td><td>!qχ’</td><td>‖qχ’</td><td>ǂqχ’*</td><td></td><td></td><td></td></tr>
<tr><td>(Pre)Voiced</td><td>ᶢʘqχ’*</td><td>ᶢ|qχ’*</td><td>ᶢ!qχ’*</td><td>ᶢ‖qχ’*</td><td>ᶢǂqχ’*</td><td></td><td></td><td></td></tr>
<tr><td rowspan="5">With uvular stop</td><td>Voiceless</td><td>ʘq*</td><td>|q*</td><td>!q</td><td>‖q</td><td>ǂq</td><td></td><td></td><td></td></tr>
<tr><td>Voiceless aspirated</td><td>ʘqʰ*</td><td>|qʰ</td><td>!qʰ</td><td>‖qʰ</td><td>ǂqʰ</td><td></td><td></td><td></td></tr>
<tr><td>(Pre)Voiced aspirated</td><td>ᶢʘqʰ*</td><td>ᶢ|qʰ*</td><td>ᶢ!qʰ*</td><td>ᶢ‖qʰ*</td><td>ᶢǂqʰ*</td><td></td><td></td><td></td></tr>
<tr><td>(Pre)Voiced</td><td>ᴺʘɢ*</td><td>ᴺ|ɢ</td><td>ᴺ!ɢ</td><td>ᴺ‖ɢ</td><td>ᴺǂɢ</td><td></td><td></td><td></td></tr>
<tr><td>(Pre)Voiced Aspirated</td><td></td><td>ᴺᴳ|qʰ*</td><td>ᴺᴳ!qʰ*</td><td>ᴺᴳ‖qʰ*</td><td></td><td></td><td></td><td></td></tr>
<tr><td>With glottalised uvular stop</td><td>Voiceless</td><td>ʘq'*</td><td>|q'</td><td>!q'*</td><td>‖q'</td><td>ǂq'*</td><td></td><td></td><td></td></tr>
<tr><td rowspan="4">Nasal</td><td>Plain</td><td>ᵑʘ*</td><td>ᵑ|</td><td>ᵑ!</td><td>ᵑ‖</td><td>ᵑǂ</td><td></td><td></td><td></td></tr>
<tr><td>Voiceless</td><td>ᵑ̊ʘ*</td><td>ᵑ̊|*</td><td>ᵑ̊!*</td><td>ᵑ̊‖*</td><td>ᵑ̊ǂ*</td><td></td><td></td><td></td></tr>
<tr><td>Voiceless aspirated</td><td>ᵑ̊ʘʰ*</td><td>ᵑ̊|ʰ</td><td>ᵑ̊!ʰ</td><td>ᵑ̊‖ʰ</td><td>ᵑ̊ǂʰ</td><td></td><td></td><td></td></tr>
<tr><td>Preglottalised</td><td>ˀᵑʘ*</td><td>ˀᵑ|</td><td>ˀᵑ!</td><td>ˀᵑ‖</td><td>ˀᵑǂ*</td><td></td><td></td><td></td></tr>
<tr><td rowspan="9">STOPS</td><td rowspan="2">Plain</td><td>Voiceless</td><td></td><td>t</td><td>ts</td><td></td><td></td><td>k</td><td>q</td><td>(ʔ)</td></tr>
<tr><td>Voiced</td><td>b</td><td>d</td><td>dz</td><td></td><td></td><td>g</td><td>ᴺɢ</td><td></td></tr>
<tr><td rowspan="2">Aspirated</td><td>Voiceless</td><td>(pʰ*)</td><td>tʰ</td><td>tsʰ</td><td></td><td></td><td>kʰ*</td><td>qʰ</td><td></td></tr>
<tr><td>(Pre)Voiced</td><td></td><td>dtʰ*</td><td>dtsʰ*</td><td></td><td></td><td>gkʰ*</td><td>ɴɢqʰ*</td><td></td></tr>
<tr><td>Glottalised</td><td>Voiceless</td><td></td><td>t'*</td><td>ts'*</td><td></td><td></td><td>k'*</td><td>q'*</td><td></td></tr>
<tr><td rowspan="2">With uvular fricative</td><td>Voiceless</td><td></td><td>tχ*</td><td>tsχ</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>(Pre)Voiced</td><td></td><td>dtχ*</td><td>dtsχ*</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">With glottalised uvular affricate</td><td>Voiceless</td><td></td><td>tqχ’*</td><td>tsqχ’*</td><td></td><td></td><td></td><td>qχ'</td><td></td></tr>
<tr><td>(Pre)Voiced</td><td></td><td>dtqχ’*</td><td>dtsqχ’*</td><td></td><td></td><td></td><td>ɢqχ'*</td><td></td></tr>
<tr><td>FRICATIVES</td><td></td><td>Voiceless</td><td></td><td></td><td>s</td><td></td><td></td><td></td><td>χ</td><td>h</td></tr>
<tr><td rowspan="2">NASALS</td><td>Plain</td><td></td><td>m</td><td></td><td>n</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Preglottalised</td><td></td><td>ˀm*</td><td></td><td>ˀn*</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Table 39. Altered symbols for sounds in !Xóõ

Original Orth.	**My symbol**	**Reason for change**
x	χ	This sound is produced with “extremely strong ‘scraping’ associated with the friction” (Traill, 1985, p. 141). The same is reported for the click accompaniments involving *x*. I represent this sound as a uvular fricative, although I follow Traill in assuming that there is some degree of pharyngealisation to this sound as well.
tshx	tsχ	These representations follow Traill (1985) and not Traill (1994). The latter creates unnecessary asymmetries in the consonant inventory.
dtshx	dtsχ	
kx’	qχ’	This symbol is used for both the ejective ‘velar’ affricate and the similar click accompaniment. [qχ’] is used, following Traill (1985) who describes

		this sound as involving pharyngeal narrowing and Naumann (2016) who considers this sound to be uvular with post-uvular frication.
t’kx’	tqχ’	These sounds involve pharyngeal narrowing and ejection on a uvular release (Traill, 1985). Traill notes that the coronal portion of the sound is not underlyingly ejected, and my orthography represents this.
dt’kx’	dtqχ’	
ts’kx’	tsqχ’	
dts’kx’	dtsqχ’	
!n	ᵑ!	Nasal clicks represented as in Sands (2020)
!n̥	ᵑ̥!	Described by Traill as being produced with voiceless nasal airflow.

Traill (1985) states that vowels in !Xóõ may be plain, nasalised, breathy, pharyngealised, glottalised, or a combination of these phonation types. Front vowels may not be pharyngealised. Pharyngealised-breathy vowels – otherwise called ‘strident’ or ‘sphyncteric’ vowels – are attested, as well as pharyngealised-glottalised vowels and, unusually, breathy-glottalised vowels. For pharyngealised vowels, Traill (1985) describes a ‘marked’ retraction of the tongue root and a lowering of the tongue body, as well as a constriction at the pharynx. The strident vowels are described as involving extreme pharyngealisation, an even lower tongue body than the pharyngealised vowels, and the epiglottis touching the back of the pharynx. Furthermore, laryngeal adjustments are made so that the epiglottis and arytenoid cartilages touch. These vowels are considered breathy as they involve strong breath-force and are as noisy as breathy vowels. Traill considers strident vowels to be phonologically pharyngealised and breathy. Glottalised vowels may have laryngealisation or a complete glottal closure interrupting a vowel. Breathy-glottalised vowels begin with breathiness that lasts for less than a mora and is followed by glottal constriction (Traill, 1985). There are co-occurrence restrictions on certain consonants and vowels that assist in building a phonological profile of !Xóõ: pharyngealised, glottalised, or breathy vowels may not follow a glottalised consonant; pharyngealised or breathy vowels may not follow aspirated or pharyngeal consonants or *x*; and breathy vowels may not follow aspirated consonants or *x* and *s* (Traill, 1985). This leads Traill to propose a ‘Single Glottal Constraint’ that states that there may be only one glottal segment per stem[20].

Traill (1985) describes six places of articulation for clicks and plosives: bilabial, dental, post-dental, palatal, velar, and uvular-pharyngeal.

The phonemic status of the glottal stop is uncertain. Preglottalised nasal clicks and stops occur, but these segments seem to be considered broadly as unitary phonemes. A glottal stop is usually inserted before vowels where the vowels would otherwise be word initial, unless the following

[20] Miller-Ockhuizen (2003) refers to the same co-occurrence restriction in Kx’a languages as the ‘Guttural OCP’.

vowels have laryngeal phonation (Naumann, 2016). Glottal stops are not attested root-medially or -finally (Vossen, 2013). I include it in the inventory table, following Traill (2018) and Naumann (2016), but it is bracketed to emphasise the uncertainty of its phonemic status.

The bilabial stop *p* is excluded from the onset inventory as it occurs only in loanwords and in one personal name, but no lexical items. Occurring in 0.94% of onsets is *b*, which is included in the table as it occurs in nine stems not marked as loanwords, but it should be considered a marginal consonant (despite not being marked as such). Aspirated *ph* occurs in one non-loanword, so is bracketed to indicate its dubious phonemic status. Traill (1985) considers *p* and *ph* to be borrowings. The ejective *p'kx'* is excluded from the onset inventory as it only occurs in one ideophone and is not considered phonemic by Traill.

Phonemes *q* and *x* are classified as uvular-pharyngeal by Traill as both are produced with pharyngeal narrowing. Traill considers the uvular plosives to be [+high], *contra* Chomsky and Halle (1968). The voiced uvular stop (as an individual phoneme or accompaniment) is produced with prenasalisation, presumably to facilitate voicing. Thus, clicks with a voiced uvular stop accompaniment are phonetically realised as [ᴺ!ɢ].

Traill (1985) differentiates between a plain palatal click [ǂ] and a palatal click + *q* [ǂq] primarily by the difference in onset time of the vowel. Clicks + *q* have a delayed VOT compared to plain clicks.

Plain aspirated clicks were found to have a uvular-pharyngeal articulation, which is why Traill transcribes them as *!qh*. Traill (2018), however, marks a distinction between clicks with an aspirated velar stop, *!kh*, and those with an aspirated uvular stop[21]. As this is not included in the dataset, I exclude it from the consonant inventory, but a phonological analysis of this language should be able to capture a distinction between these two sounds.

Ejective clicks are recorded by Naumann (2016) for Taa and are considered contrastive with glottalised clicks. Nakagawa (2006) recorded ejective clicks that contrast with glottalised clicks in G|ui, a Khoe-Kwadi language that has historically been in contact with !Xóõ (Sands, 2001). Nakagawa found that ejective and glottalised clicks differed in nasality – the former was never produced with nasal airflow or intervocalic nasality, whereas the latter was.

[21] Sands (2020) argues that the distinction between *!kh* and *!qh* is not so much one of timing of the release burst but of the position of posterior closure. I interpret *!kh* as a plain aspirated click, however.

It is evident that nasal clicks have fewer phonation types than oral clicks. Naumann (2016) attributes this asymmetry to nasals lacking release bursts which prevents them from having as many phonation types as pulmonic or lingual obstruents. Naumann (2016, p. 15) considers the class of nasals to defined by “complete oral closure and the presence of a nasal airstream”, based (Ladefoged & Maddieson, 1996). Thus, in this interpretation, voiced and voiceless nasal clicks are grouped with nasal stops. However, nasal clicks do not behave like other sonorants and are not permitted to occur as root-internal consonants.

5.2.4 N|uu

Table 40. Inventory of N|uu word-initial onsets

<table>
<tr><th colspan="3" rowspan="2">N|UU onsets</th><th rowspan="2">Bilabial</th><th rowspan="2">Dental</th><th colspan="2">Alveolar</th><th rowspan="2">Postalveolar / Palatal</th><th rowspan="2">Velar</th><th rowspan="2">Uvular</th><th rowspan="2">Glottal</th></tr>
<tr><th>CENTRAL</th><th>LATERAL</th></tr>
<tr><td rowspan="14">CLICKS</td><td rowspan="2">Plain</td><td>Voiceless</td><td>ʘ</td><td>ǀ</td><td>ǃ</td><td>ǁ</td><td>ǂ</td><td></td><td></td><td></td></tr>
<tr><td>Voiced</td><td></td><td>ᶢǀ</td><td>ᶢǃ</td><td>ᶢǁ</td><td>ᶢǂ</td><td></td><td></td><td></td></tr>
<tr><td>Aspirated</td><td>Voiceless</td><td></td><td>ǀʰ</td><td>ǃʰ</td><td>ǁʰ</td><td>ǂʰ</td><td></td><td></td><td></td></tr>
<tr><td>Glottalised</td><td>Voiceless</td><td>ᵑ̊ʘˀ*</td><td>ᵑ̊ǀˀ</td><td>ᵑ̊ǃˀ</td><td>ᵑ̊ǁˀ</td><td>ᵑ̊ǂˀ</td><td></td><td></td><td></td></tr>
<tr><td>With uvular fricative</td><td>Voiceless</td><td>ʘχ*</td><td>ǀχ*</td><td>ǃχ</td><td>ǁχ</td><td>ǂχ</td><td></td><td></td><td></td></tr>
<tr><td>With glottalised uvular</td><td>Voiceless</td><td>ʘχ'*</td><td>ǀχ'</td><td>ǃχ'</td><td>ǁχ'</td><td>ǂχ'</td><td></td><td></td><td></td></tr>
<tr><td rowspan="3">With uvular stop</td><td>Voiceless</td><td>ʘq*</td><td>ǀq</td><td>ǃq</td><td>ǁq</td><td>ǂq</td><td></td><td></td><td></td></tr>
<tr><td>Voiceless aspirated</td><td></td><td>ǀqʰ</td><td>ǃqʰ</td><td>ǁqʰ</td><td>ǂqʰ</td><td></td><td></td><td></td></tr>
<tr><td>(Pre)Voiced</td><td></td><td>ᶢǀq*</td><td>ᶢǃq*</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Nasal</td><td>Plain</td><td>ᵑʘ*</td><td>ᵑǀ</td><td>ᵑǃ</td><td>ᵑǁ</td><td>ᵑǂ</td><td></td><td></td><td></td></tr>
<tr><td>Voiceless aspirated</td><td></td><td>ᵑ̊ǀʰ</td><td>ᵑ̊ǃʰ</td><td>ᵑ̊ǁʰ</td><td>ᵑ̊ǂʰ</td><td></td><td></td><td></td></tr>
<tr><td rowspan="5">STOPS</td><td rowspan="2">Plain</td><td>Voiceless</td><td>(p)</td><td></td><td>ts</td><td></td><td>c*</td><td>k</td><td>q*</td><td>(ʔ)</td></tr>
<tr><td>Voiced</td><td>(b)</td><td></td><td>tsʰ*</td><td></td><td>ɟ</td><td>g</td><td>ɢ̊*</td><td></td></tr>
<tr><td>Aspirated</td><td>Voiceless</td><td>(pʰ*)</td><td></td><td></td><td></td><td>cʰ*</td><td>kʰ</td><td></td><td></td></tr>
<tr><td>Glottalised</td><td>Voiceless</td><td></td><td></td><td>ts'</td><td></td><td>c'*</td><td></td><td></td><td></td></tr>
<tr><td>With glottalised uvular</td><td>Voiceless</td><td></td><td></td><td></td><td></td><td>(t̪s̪χ*)</td><td>kχ'</td><td></td><td></td></tr>
<tr><td rowspan="2">FRICATIVES</td><td></td><td>Voiceless</td><td></td><td></td><td>s</td><td></td><td></td><td></td><td>χ</td><td>ɦ</td></tr>
<tr><td></td><td>Voiced</td><td></td><td></td><td>z*</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>NASALS</td><td></td><td></td><td>m*</td><td></td><td>n*</td><td></td><td>ɲ*</td><td></td><td></td><td></td></tr>
</table>

Table 41. Altered symbols for sounds in N|uu

Original Orth.	**My symbol**	**Reason for change**
x	χ	Described as uvular by Miller, Brugman, et al. (2007).
h	ɦ	The glottal fricative varies in its production between [h] and [ɦ]. I use [ɦ] as it is the more common form.

N|uu has five vowel types – *a, e, i, o,* and *u* – and modal, nasalised, epiglottalised, and nasal epiglottalised phonation types (Miller, Brugman, et al., 2007). Epiglottalisation is also referred to as pharyngealisation in the N|uu dictionary (Sands & Jones, 2022).

The N|uu dictionary by Sands and Jones (2022) includes IPA transcriptions of each entry, which were included in the frequency tables in the results section, so I mostly follow those transcriptions in my onset consonant table.

In the dictionary, *b* occurs only twice in roots that are not clear loanwords. It is not statistically marginal as many loanwords occur, but it is not commonly observed in the onsets of non-loaned words. Similarly, *p* and *ph* each occur once in one word that isn't clearly loaned. Thus, I include these sounds in the onset inventory but bracket them as I am not sure if they originate in N|uu Similarly, the status of the glottal stop is uncertain. I follow Miller et al. (2009) who consider it to be prosodically conditioned rather than phonemic, but include it bracketed in their inventory.

It appears that dental stops in N|uu have been lost or become palatalised, given the lack of a dental stop series. Palatalisation seems to be a fairly common process within KBA languages, as attested in G|ui (Nakagawa, 1996). In N|uu, there is a palatal stop series, as well as a stop series that are spelled in the N|uu dictionary as *tsy* and represented in IPA as [t̻s̻] (Sands & Jones, 2022). The latter is not included in Miller, Brugman, et al. (2007)'s consonant inventory. I suspect that the [t̻s̻]-series is the palatalised form of [ts], although [ts] has not fully shifted from the alveolar place to the palatal one. Sands and Jones (2022) use *cx* to represent the sound [t̻s̻χ], so there seems to be some conflation between the palatal stop series and the laminal affricate series. It is possible that the contrast between the two is collapsing in N|uu, as illustrated by the following N|uu-!Xóõ entries that I believe to be cognate:

Table 42. Possible N|uu-!Xóõ cognates for N|uu [t̻s̻χ]

N|uu	**!Xóõ**	**Gloss**
cxaa [t̻s̻χɑɑ]	*dtxàa*	to tear (N|uu), to split (!Xóõ)
cxan [t̻s̻χən]	*tshxàã*	shit
cxum [t̻s̻χum]	*txóm*	to thread

There is one minimal pair for [cʰ] and [t̻s̻ʰ], but otherwise the [c]-series, [ts]-series, and the [t̻s̻]-series show a fair amount of synonymy. Furthermore, the [ts]-series includes roots with variants beginning with [s]. Thus, the coronal egressive stop series seem to be particularly unstable. It should not be assumed that there are three coronal egressive stop series in N|uu. I do not include the [t̻s̻]-series in my onset inventory as I assume that these sounds are variants of the strident coronal stop series or the palatal stop series. The sound *cx* is included in previous inventories, so I include it in mine as [t̻s̻χ] and bracket it to represent the collapse of the dental and palatal contrasts.

Miller, Brugman, et al. (2007) include both *kᵡ'* and *qᵡ'* in their inventory. They emphasise that the former is a heterorganic affricate. The latter is unattested in the dictionary, so I exclude it. A devoiced uvular stop, *gq* or [ɢ̊], exists in three entries. I include it as it does not seem to be a variant of another sound. This sound is not attested in Miller, Brugman, et al. (2007). A velar nasal, *ng*, occurs but is syllabic so is not included in the onset table.

Both liquids, *r* and *l*, have been excluded as they only occur in loanwords, *contra* Miller, Brugman, et al. (2007).

Representation of clicks in my table follows the IPA used in Sands and Jones (2022). Of interest is the voicing alternation of nasal clicks between the Eastern and Western dialect. The former tends to nasally voice clicks with nasal venting. Thus, [ᵑ‖ˀ] exists in the Eastern dialect as a variant of the glottalised click. Moreover, clicks with voiceless nasal aspiration in the Western dialect are produced as nasal aspirated clicks in the Eastern dialect. I retain the more common transcription of clicks with nasal venting in my table, corresponding to segments in the Western dialect segment. The variability in nasal voicing, however, suggests that these clicks are phonologically nasal.

There is also some variation among oral clicks – [|χ'] has a [|q'] variant; [!qʰ] has one [!χ] variant; [!χ'] has variant forms beginning with [!q'], [!qʰ], and [!q]; [‖χ'] has a [‖k'] and a [‖q'] variant; [‖qʰ] is sometimes produced as [‖χ] and other times as [‖h]; [ǂq] has [ǂqh] and [ǂ] variants; [ǂχ] has [ǂx], [ǂkh], [ǂh], and [ǂkx] variant forms. There are two entries beginning with [ᶢ|q] that have [|q], [|ɢ], and [|ʁ] variant forms. There are also three entries beginning with [ᶢ!q]. I include these prevoiced clicks with a uvular stop in the consonant inventory, although these are not included in Miller, Brugman, et al. (2007), as I think that these sounds might be remnants of a previous sound system that did maintain voicing contrasts much like !Xóõ. I believe that the extensive variation is probably an effect of the moribund nature of N|uu. With few speakers left, it is possible that phonological contrasts are breaking down. It is also notable that the sounds that are displaying a lot of variation in their production are also displaying inconsistent adherence to the 'Single Glottal Constraint', possibly also due to the moribund status of the language.

A total of nine entries beginning with *|'*, *!'*, and *ǂ'* have no nasal venting – this may be an ejected click similar to those observed in G|ui (Nakagawa, 2006). In the N|uu dictionary, however, the orthography for glottalised clicks with and without nasal venting is the same so I have not included an ejected click in the consonant inventory. Similarly, some entries beginning with clicks with delayed aspiration are produced without nasal venting.

Regarding the posterior closure of clicks, Miller, Brugman, et al. (2007) report that spectrograms of plain clicks do not indicate a pulmonic burst after the anterior release of the click. Previous descriptions have claimed that plain clicks have a weak velar plosive posterior release, but this is not detected in the waveforms or acoustic recordings by Miller et al. They note that Traill (1985) observes the same for plain clicks in !Xóõ, writing that the posterior closure may be released inaudibly. Furthermore, Miller, Brugman, et al. (2007) record a post-velar closure for all click types in N|uu. They find that the upper portion of the tongue root is more retracted in the posterior closure of [!] than it is for the closure of [k] and is a little more retracted than it is for the closure of [q]. Thus, they treat [!] as an ‘alveo-uvular’ segment. In the production of the palatal click [ǂ], the upper tongue root is raised and the dorsum is retracted, creating a more posterior closure in the ‘upper pharynx’ than that of the alveolar click. Because of this, they call [ǂ] a ‘palato-pharyngeal’ segment. Miller, Brugman, et al. (2007) suggest that the posterior closure of [ǁ] is similar to that of [!], and the posterior closure of [|] is similar to that of [ǂ]. Thus, Miller et al. propose a [pharyngeal] feature for [ǂ] and [|]. Importantly, Miller, Brugman, et al. (2007) also find that the pulmonic burst in clicks + *q* has the same place of articulation as the posterior constriction of the click portion of the segment. That is, although the transcription implies that these are clicks with a uvular stop, the anterior click closure and pulmonic burst are homorganic. Thus, the only difference between plain clicks and clicks + *q* is an airstream contour. Miller et al. also suggest that the same is true of clicks in !Xóõ. Finally, clicks with a uvular fricative are associated with a strong ‘scraping’ sound, “as would be expected of a uvular or uvulo-pharyngeal fricative” (Miller, Brugman, et al., 2007, p. 137).

5.2.5 Ju|’hoan

Table 43. Inventory of Ju|'hoan word-initial onsets

JU ǀ'HOAN onsets			Bilabial	Dental	Alveolar		Postalveolar / Palatal	Velar	Uvular	Glottal
					CENTRAL	LATERAL				
CLICKS	Plain	Voiceless		ǀ	!	ǁ	ǂ			
		(Pre)Voiced		ᶢǀ	ᶢ!	ᶢǁ	ᶢǂ			
	Aspirated	Voiceless		ǀʰ	!ʰ	ǁʰ*	ǂʰ			
		(Pre)Voiced		ᶢǀʰ*	ᶢ!ʰ*		ᶢǂʰ*			
	Glottalised	Voiceless		ǀˀ	!ˀ	ǁˀ	ǂˀ			
	With dorsal fricative	Voiceless		ǀχ	!χ	ǁχ	ǂχ			
		(Pre)Voiced		ᶢǀχ*	ᶢ!χ*	ᶢǁχ*	ᶢǂχ*			
	With glottalised dorsal affricate	Voiceless		ǀkχ'	!kχ'	ǁkχ'	ǂkχ'*			
		(Pre)Voiced		ᶢǀkχ'*	ᶢ!kχ'*	ᶢǁkχ'*	ᶢǂkχ'*			
	Nasal	Plain		ᵑǀ	ᵑ!	ᵑǁ	ᵑǂ			
		Voiceless aspirated		ᵑ̥ǀʰ	ᵑ̥!ʰ	ᵑ̥ǁʰ	ᵑ̥ǂʰ			
		Voiced Aspirated		ᵑǀʰ*	ᵑ!ʰ	ᵑǁʰ	ᵑǂʰ			
STOPS	Plain	Voiceless	p		t			k		(ʔ)
		Voiced	b		d			g		
	Aspirated	Voiceless	pʰ*		tʰ			kʰ		
		(Pre)Voiced	bpʰ*		dtʰ*			gkʰ*		
	With dorsal fricative	Voiceless			tχ*					
		(Pre)Voiced			dtχ*					
	With glottalised dorsal affricate	Voiceless			tkχ'*					
AFFRICATES	Plain	Voiceless			ts		tʃ			
	Aspirated	Voiceless			tsʰ*		tʃʰ			
		(Pre)Voiced			dtsʰ*		dtʃʰ*			
	Glottalised	Voiceless			ts'		tʃ'*	kχ'		
		(Pre)Voiced			dts'*		dtʃ'*			
	With dorsal fricative	Voiceless			tsχ*		tʃχ*			
		(Pre)Voiced			dtsχ*		dtʃχ*			
FRICATIVES	Plain	Voiceless			s		ʃ		χ	ɦ
		Voiced			z		ʒ			
NASALS			m		n					
APPROXIMANTS							j*	w*		

Table 44. Altered symbols for sounds in Ju|’hoan

Original Orth.	**My symbol**	**Reason for change**
c	ʃ	Following Dickens (1994)’s IPA symbol for these sounds.
j	ʒ	
dzx	dtsχ	I represent these segments as prevoiced affricates so that the symmetry of each pulmonic affricate and stop series is preserved, but consider these sounds phonologically [+voice].
djx	dtʃχ	
χ	χ	Miller-Ockhuizen (2003) and Vossen (2013) describe this sound as uvular.
kx’	kχ’	Described by Miller-Ockhuizen (2003, p. 51) as involving “a period of uvular frication which is followed temporarily by a period of glottal abduction.”
!h	!ʰ	Described by Dickens (1994) as ‘velar-audible’ or ‘short’ aspiration. Interpreted by Sands (2020) as a plain aspirated click.

!’h	ᵑ!̥ʰ	Dickens describes this as ‘velar-inaudible’ or ‘long’ aspiration, which Sands (2020) analyses as delayed aspiration/voiceless nasal aspiration.
n!h	ᵑ!ʰ	A voiced nasal version of Dickens’s ‘long’ aspiration.
!’	!ˀ	This click is glottalised, not ejected. Nasal venting is left unmarked, but Miller (Vossen, 2013) describes the glottalised click as a ‘voiceless nasal ingressive’, so some nasal venting is probably present.
n!	ᵑ!	Nasalisation is represented with superscript.

The vowel types of Ju|’hoan are *a, e, i, o,* and *u.* A raised variant of /ɑ/ pronounced as [ə] occurs before high vowels and [m]. Furthermore, /i/ and /e/ have diphthongised allophones – [əi] and [əe] respectively – that surface after “consonants with secondary dorsal articulations” (Vossen, 2013, p. 140). Vowels in Ju|’hoan may be modal, nasal, breathy, glottalised, or epiglottalised (Vossen, 2013). Dickens (1994) refers to epiglottalised vowels as pharyngealised or ‘pressed’. Miller-Ockhuizen (2003, p. 68) describes epiglottalised vowels as involving “extreme retraction of the tongue root and commensurate retraction of the epiglottis, which results in lower, more back vowels than are found in their non-epiglottalised counterparts.” Nasalisation may co-occur with other phonation types, but laryngeal phonation types never co-occur on the same vowel. Furthermore, laryngeal vowel phonation types do not co-occur with aspirated, glottalised or ‘uvularized’ consonants (Miller-Ockhuizen, 2003), so Miller-Ockhuizen posits a ‘Guttural OCP constraint’ that prohibits a root from having multiple ‘guttural’[22] or laryngeal features.

The glottal stop is not recorded explicitly in Dickens (1994), so was not included in the frequency calculations and O/E ratios. It is included in Miller’s consonant inventories (Miller-Ockhuizen, 2003; Vossen, 2013), but it is bracketed in my inventory as it only seems to occur in the onset position of root-initial syllables that would otherwise begin with a vocoid.

Ju|’hoan has a four-way VOT contrast for plosives (including oral clicks): voiceless, voiced, voiceless aspirated, and (pre)voiced aspirated. There is also a voiceless-voiced contrast for coronal fricatives [s, z] and [ʃ, ʒ]. Nasal clicks have fewer VOT contrasts. It should also be noted that plain pulmonic stops may not be ejective, but pulmonic affricates may be ejective. Voicing for many segments is realised as voice-lead, especially for ejective segments or voiced clicks. Snyman (1970) describes this voice-lead as an unemitted sound preceding the rest of the

[22] Miller uses ‘guttural’ to describe the laryngeal or pharyngeal properties of non-modal and non-nasal vowel phonation types, and that of certain consonantal releases, as well as uvular and epiglottal consonants (Miller-Ockhuizen, 2003).

consonant. Non-ejective voiced sounds may be produced with voicing throughout the release of the sound, so I consider voicing to be phonological and for the voice-lead in ejectives and clicks to be a phonetic by-product of complex articulatory processes that may inhibit voicing.

I omit the central liquid *r* as it occurs only in a few loanwords and two grammatical particles.

5.2.6 Ekoka !Xun

Table 45. Inventory of Ekoka !Xun word-initial onsets

NW !XUN onsets			Bilabial	Dental	Alveolar		Postalveolar / Palatal	Velar / Uvular	Glottal
					CENTRAL	LATERAL			
CLICKS	Plain	Voiceless		ǀ	ǃ	ǁ	ǂ		
		(Pre)Voiced		ᶢǀ	ᶢǃ	ᶢǁ	ᶢǂ		
	Aspirated	Voiceless		ǀʰ	ǃʰ	ǁʰ	ǂʰ		
		(Pre)Voiced		ᶢǀʰ*	ᶢǃʰ*	ᶢǁʰ*	ᶢǂʰ*		
	Glottalised	Voiceless		ǀˀ	ǃˀ	ǁˀ	ǂˀ		
	With dorsal fricative	Voiceless		ǀχ	ǃχ	ǁχ	ǂχ		
		(Pre)Voiced		ᶢǀχ*	ᶢǃχ*	ᶢǁχ*	ᶢǂχ*		
	With glottalised dorsal affricate	Voiceless		ǀkχ'	ǃkχ'	ǁkχ'	ǂkχ'*		
		(Pre)Voiced		ᶢǀkχ'*	ᶢǃkχ'*	ᶢǁkχ'	ᶢǂkχ'*		
	Nasal	Plain		ᵑǀ	ᵑǃ	ᵑǁ	ᵑǂ		
		Voiceless aspirated		ᵑ̥ǀʰ	ᵑ̥ǃʰ	ᵑ̥ǁʰ	ᵑ̥ǂʰ		
		Aspirated		ᵑǀʰ*	ᵑǃʰ*	ᵑǁʰ	ᵑǂʰ*		
		Preglottalised		ˀᵑǀ	ˀᵑǃ*	ˀᵑǁ*	ˀᵑǂ*		
STOPS	Plain	Voiceless	p*		t			k	(ʔ)
		Voiced	b		d			g	
	Aspirated	Voiceless	pʰ*		tʰ			kʰ	
		Voiced	bʰ*		dʰ*			gʰ*	
	With dorsal fricative	Voiceless			tχ*				
		(Pre)Voiced			dtχ*				
	With glottalised dorsal affricate	Voiceless			tkχ'*			kχ'	
		(Pre)Voiced						gkχ'*	
AFFRICATED STOPS	Plain	Voiceless					tʃ		
		Voiced					dʒ		
		(Pre)Voiced					dtʃ*		
	Aspirated	Voiceless					tʃʰ*		
		(Pre)Voiced					dtʃʰ*		
	Glottalised	Voiceless					tʃ'		
		(Pre)Voiced					dtʃ'*		
	With dorsal fricative	Voiceless					tʃχ		
		(Pre)Voiced					dtʃχ*		
	With glottalised dorsal affricate	Voiceless					tʃkχ'*		
		(Pre)Voiced					dtʃkχ'*		
FRICATIVES							ʃ	χ	ɦ
NASALS	Plain		m		n				
	Aspirated				nʰ*				
	Preglottalised				ˀn*				
APPROXIMANTS							j*	w*	

The representational system used in König and Heine (2008) mostly follows the orthographic conventions of Dickens (1994). Thus, the changes described for Ju|'hoan are retained here. The following section will only describe any additional changes and any relevant instances where König and Heine (2008) deviated from Dickens.

Table 46. Altered symbols for sounds in Ekoka !Xun

Original Orth.	**My symbol**	**Reason for change**
tx ~ tk	tχ (~ tk)	These uncommon sounds are represented in the same way as similar sounds in Ju|’hoan.
dx	dtχ	
tx’	tkχ’	
!!	ǂ	König and Heine (2008) refer to this as a ‘retroflex’ click but subsequent analyses have found this sound to be cognate with the palatal click in Ju|’hoan and suggest the symbol used here (Fehn, 2020; Sands, 2020). This palatal click is not abrupt, but is produced with frication (Miller & Holliday, 2014).
’n!	ˀŋ!	Described as preglottalised click (König and Heine, 2008).

Ekoka !Xun has four vowel phonation types as described by König and Heine (2008); oral, breathy, pharyngeal, and nasal. Nasalisation may co-occur with other phonation types, but no other combinations are permitted. Only back vowels may be pharyngeal. König and Heine assume that an intervocalic glottal stop acts as a consonant, but also observe that it is often produced very weakly. Given that Ju|’hoan has a glottalised vowel type and that the glottal stop is not usually attested in Ju|’hoan as a medial consonant (Vossen, 2013), I suggest that the intervocalic glottal stop is actually vowel laryngealisation/glottalisation. If this is true, then the glottal stop exists as an independent consonant only when it is inserted into root-onsets to prevent vowel-initial words, so I include it in brackets in the onset consonant inventory.

The set of post-alveolar/palatal affricates may vary in their place of production from alveolar to palatal, even within one dialect (Heine & König, 2015).

König and Heine (2008) record a few ‘voiced fortis stops’ *dth* and *gkh* that apparently contrast with the voiced aspirated stops *dh* and *gh*. This distinction is not upheld in the phoneme inventory in Heine and König (2015), so I omit the ‘fortis stops’ from the onset inventory. It would be highly irregular to have a four-way VOT system for most segments and then a five-way VOT system for selected stops.

There are some roots that begin with *kw* or *khw*. All *kw* roots and three of the four *khw* roots are grammatical particles, so I assume that the glide is a product of vowel reduction in non-lexical morphemes and do not include these sounds in the onset inventory. Similarly, eight roots with prenasalised stops (*nd, ndj, ng,* and *nj*) occur. Some of these occur in loanwords and others are demonstratives or particles. The root beginning with *nj* is a variant of a word beginning with *dj* and there are similar correspondences for some of the demonstratives, so I suggest that this transcription might result from the ambiguity of prevoicing, as – at least in Ju|’hoan – voicing may sound like an unemitted sound before a stop. Thus, I do not consider these sounds to contrast with other prevoiced stops. It should be noted that Heine and König (2015) include a set of prenasalised stops – *mb, nd,* and *ng* – in their inventory. The dictionary (König & Heine, 2008) has no entries beginning with *mb*.

The lateral liquid *l* occurs only in a few loanwords and in three grammatical particles, so is excluded.

6 Discussion

The results provide information about the frequency of onsets, the phonological patterns within which these onsets participate, and the language-specific onset consonant inventories. This information is vital in the formulation of a phonological analysis of the KBA languages. The discussion is split into three sections. Section 6.1 deals with the assessment of the BVC in each language. This constraint underpins many phonological analyses of clicks or onsets and is equally important here. Information pertaining to the BVC is necessary for determining the tongue features needed to capture phonological contrasts in each language, which will be referred to in the last section of my discussion. Section 6.2 investigates the cluster versus unit debate regarding onsets and evaluates evidence for a cluster analysis in each language. Section 6.3 assesses previous formal representations of sounds in KBA languages and proposes an alternative feature geometry for the representation of onsets. The conclusions drawn in this section are predicated upon the phonological information that has been presented thus far.

6.1 Is the Back Vowel Constraint a phonological reality?

Understanding the extent of the phonological reality of the BVC is vital for the formulation of a full feature geometry representation of onsets in KBA languages, as it changes the way that 'back' sounds are analysed. Miller, Namaseb, et al. (2007) have argued that, at least for Khoekhoegowab, this constraint may be physiological rather than phonological, whereas others – including but not limited to Halle (1995), Nakagawa (2006), and Traill (1985) – have taken it to be phonological. Although this question seems orthogonal to the research questions of this project, assumptions about the interaction between front vowels and back consonants underpin much of the analysis, and a full representational system of sounds depends on the phonological status of this constraint. This section will investigate trends in the frequency tables and attempt to draw a conclusion about this topic.

A few general trends can be observed. Firstly, across every language included in this study, front vowels occur less frequently than they would if vowel distribution was equally divided. There seems to be a general dispreference for front vowels, especially in lexical roots. Grammatical items seem more permissive. Secondly, there are usually exceptions to the BVC. For example, *k* in !Xóõ is not usually followed by front vowels, but some co-occurrences are observed. This inconsistency makes the constraint harder to assess. Thirdly, front vowels are permitted after back consonants in loanwords in many languages. Not many of these loanwords occur, but where they are, the original vowel seems to be preserved. This is not hard evidence, as loanwords may violate other phonotactic restrictions in KBA languages such as word-medial clusters, but it may indicate that there is either no phonological process that systematically retracts front vowels or that it is not an articulatory constraint as these sound sequences are able to be produced. Further research is required. Finally, the extent to which back vowels seem to be prohibited from following certain consonants seems to vary between languages. If the BVC is solely an articulatory effect, one would not expect extensive variation between languages with similar sounds. More investigation needs to be undertaken regarding this topic.

In the subsections below, the patterns of front vowel occurrence in each language are briefly described. These patterns seem to show that the strength of the BVC varies from language to language, even within language families.

6.1.1 Khoekhoegowab

In Khoekhoegowab, egressive bilabial and coronal oral obstruents are followed by front vowels around 20% of the time. These sounds should not be subject to the BVC, so deviation from this rate of front vowel co-occurrence may suggest that the BVC is in effect. In comparison, [k] is only followed by front vowels in around 9.76% of entries and 60% of those are loanwords. The rate of co-occurrence falls to 2.82% for front vowels after [kx^h] and 4.3% after [x].

Dental and palatal clicks co-occur with front vowels more frequently than alveolar and lateral clicks, but the latter are not prohibited from co-occurring with front vowels. Clicks with aspiration/velar affrication also co-occur with front vowels. The palatal and dental clicks with aspiration/velar affrication are respectively followed by front vowels in 14.47% and 17.65% of entries, and the alveolar and lateral clicks are followed by front vowels in 3.25% and 4.9% of entries.

These patterns show that there is some dispreference for front vowels following velar stops and alveolar and lateral clicks, but there is no absolute prohibitory effect. Thus, the BVC may be weak or may be a phonetic effect in Khoekhoegowab.

6.1.2 Khwe

Coronal segments – especially palatal ones – seem to condition vowel fronting in Khwe. [ʃ] is followed by a front vowel 47.37% of the time (although many of these items are loanwords).

The coronal stops [t] and [d] are followed by front vowels 34.69 and 57.97% of the time, respectively, and [tʃ] is followed by front vowels 49.5% of the time.

Clicks do not seem to be affected by back vowel restrictions. Plain palatal and dental clicks are followed by front vowels 29.56% and 24.14% of the time, while the lateral click is followed by front vowels in 17.02% of entries[23]. The higher rate for dental and palatal clicks is likely a result of fronting before a coronal segment, as this seems to be a common pattern in Khwe. Segments with dorsal frication or affrication such as [x], [kx'], and clicks/stops with these accompaniments may be followed by front vowels, with front vowels even occurring after [tx] in 33.33% of entries. Egressive velar stops are also followed by front vowels. The uvular plosive [q] is also followed by front vowels in 10% of entries.

It seems that an assimilatory process of fronting is active in Khwe, where coronal stops induce front vowels to occur more frequently than expected. This effect may extend to palatal and dental clicks, after which front vowels occur more frequently than after lateral clicks. There does not seem to be a BVC effect in Khwe.

6.1.3 !Xóõ

Front vowels are particularly rare in !Xóõ, recorded as occurring after only 122 onsets out of 3076. !Xóõ has almost no co-occurrences between clicks and front vowels. The exceptions include some members of the dental click series, which are followed by front vowels around between 3 and 8% of the time; some members of the palatal click series, which are followed by front vowels between 2 and 17% of the time; and the aspirated alveolar and lateral clicks, and the glottalised lateral click, which are each followed once by a front vowel. It is notable that dental and palatal clicks with uvular plosive accompaniments may be followed by front vowels. There are no co-occurrences between front vowels and any click or stop with a uvular fricative/affricate.

No uvular obstruents are followed by front vowels and the same is mostly true for velar stops (a total of two exceptions occur in the velar stop series). It seems that front vowels are generally dispreferred, occurring between 2 and 18% of the time after some egressive coronals.

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[23] The alveolar click is not included here as its frequency is too low for meaningful conclusions to be drawn.

Thus, there seems to be a BVC that occurs in !Xóõ and targets dorsal consonants. The dorsal consonants that seem particularly targeted by this constraint are the bilabial, lateral, and alveolar click series, and egressive uvular obstruents. There may be a stronger prohibition against uvular consonants being followed by front vowels than velar consonants.

6.1.4 N|uu

N|uu does not have front vowels following any bilabial clicks, and generally prohibits them from following lateral and alveolar clicks. Palatal and dental clicks may be followed by front vowels unless these clicks have a dorsal fricative/affricate release (although a few exceptions occur).

Egressive velar stops are allowed to be followed by front vowels, whereas uvular stops are not. Front vowels occur after [k] in 23 out of 66 entries, and after [g] in 4 of 14 entries. Uvular stops are less frequent than velar ones, however, so it is difficult to ascertain the strength of this prohibitory effect. The uvular fricative is followed by a front vowel once out of 28 entries.

A version of the BVC seems to be active in N|uu, although it seems to target only /i/. My dataset includes some 'back' consonants co-occurring with /e/. Miller (2010) observes that N|uu /i/ has a diphthongised allophone [əi] that occurs after uvulars [q] and [χ], as well as after clicks in the labial, alveolar, and lateral click series. Miller also observes that egressive labials, coronals, and velars, and palatal and dental clicks – as well as those with a uvular plosive release – allow [i] to follow them. This pattern is confirmed in my dataset, which also shows that alveolar or lateral clicks with a dorsal fricative may cause the following /i/ to be realised as a voiced uvular fricative [ʁ]. Furthermore, the velar stops [k] and [g] do not seem to be affected by the BVC.

6.1.5 Ju|'hoan

Front vowels occur infrequently in Ju|'hoan. No front vowels follow any oral clicks and most nasal clicks in my dataset. The nasal dental click is followed by front vowels in 4.17% of entries beginning with this onset. The nasal alveolar click is followed by a front vowel once. This is probably an effect of orthography more than phonology as Dickens (1994) renders [əi] or [i] as *ai*, which he takes to be the underlying form that is raised in certain environments. I follow Miller-Ockhuizen (2003), who considers [əi] to be a lowered allophone of [i], and records it as occurring after [χ], [q], [ʘ], [!], [ǁ], [ʘq], [!q], and [ǁq]. In my data, the dorsal fricative is never followed by front vowels, and nor is any segment that has a dorsal fricative or affricative component. Plain egressive velar stops are infrequently followed by front vowels, but co-occurrences do occur. Aspirated egressive velar stops are never followed by front vowels.

Front vowels are unexpectedly common after aspirated coronal affricates, occurring much more frequently than after plain coronal affricates. Front vowels follow [dts^h] and [dtʃ^h] 50% and 55.56% of the time, respectively, and [ts^h] and [tʃ^h] 56.25% and 65.22% of the time. In comparison, front vowels occur after the plain voiceless coronal affricates between 15 and 22% of the time. This may indicate a fronting assimilatory effect for the aspirated coronal affricates. Furthermore, no front vowels occur after [t^h], but this may be due to an accidental gap.

Thus, in Ju|’hoan, I assume that the BVC is active for the alveolar, lateral, and bilabial clicks, as well as uvular segments. I also assume that front vowels are generally dispreferred, but that they generally may occur or be conditioned to surface after coronal segments.

6.1.6 Ekoka !Xun

In Ekoka !Xun, dental and palatal clicks tend to co-occur with front vowels, and alveolar and lateral clicks tend not to do so. No segments with a dorsal fricative or affricative component are followed by front vowels. Plain velar plosives are followed by some front vowels, but aspirated velar plosives are not. Egressive coronal stops and affricates may be followed by front vowels.

In Ekoka !Xun, there seems to be a constraint working against the co-occurrence of front vowels and alveolar clicks, lateral clicks, and segments with dorsal frication/affrication.

6.1.7 Section summary

This section provides evidence for a phonologically active BVC in the Tuu and Kx’a languages, but not necessarily for the Khoe-Kwadi languages. For the languages with an active BVC, uvular sounds, ‘back’ clicks, and segments with dorsal frication or ejective affrication seem most affected by this constraint. Velar obstruents may be less affected by it. In !Xóõ and N|uu, a salient pattern is observed regarding the production of clicks with a uvular plosive accompaniment. Palatal and dental clicks with uvular plosive releases tend not to pattern as uvular segments with respect to the BVC. This is evidence for uvulars and alveolar, lateral, and bilabial clicks sharing a feature that is not permitted to occur with a following front vowel. It is also evidence for the uvular plosive release of ‘front’ and ‘back’ clicks being phonologically distinct.

6.2 Assessment of onsets as clusters or units

The following section addresses previous literature that argues for a cluster or unit analysis of onsets in KBA languages (6.2.1) and then assesses evidence regarding the phonological status of the onsets in each language (6.2.2).

The arguments made in this section are premised upon the categorization of clicks as obstruents, as argued by Traill (1985) and Miller (2011). Clicks are taken to be the least sonorant type of segment (Traill, 1985).

6.2.1 Response to previous literature

6.2.1.1 The cluster analysis

The first argument made by proponents of cluster analysis is the typological argument: analysing segments in KBA languages as clusters drastically reduces the number of consonants, bringing these languages in line with cross-linguistic typological norms. As noted by researchers such as Brugman (2009), Miller (2011), and Bennett (2020), the cluster analysis causes KBA languages to be at odds with other typological norms. The types of clusters that are cross-linguistically 'privileged' – a coronal sibilant plus another consonant, an obstruent plus a sonorant, and a nasal plus another consonant – do not occur in KBA languages (Bennett, 2020)[24]. 'Clusters' that are attested in KBA languages are OO clusters and are composed either of two stops or a stop followed by a fricative (assuming clicks are stops). No clusters of clicks with liquids or glides exist, which contradicts generalisations about sonority sequencing within onsets, such as the Minimal Sonority Distance principle and the Sonority Dispersion principle. Moreover, the occurrence of only OO clusters that are stop-stop or stop-fricative sequences is highly typologically usual according to Kreitman (2008) and Morelli (1999). Kreitman found that, across 62 languages, OO clusters only existed in languages that also had OS clusters, whereas OS clusters could occur in languages without OO clusters. Thus, there seems to be an implicational universal governing the occurrence of clusters, with OS clusters being the unmarked cluster type. Morelli found that there is a markedness hierarchy within OO clusters, concluding that fricative-stop clusters are least marked, and that stop-stop and stop-fricative

[24] The 'nasal plus consonant' type is attested only if these sounds are not analysed as prenasalised stops. Prenasalised segments are usually present in KBA onset inventories due to borrowing from a neighbouring Bantu language or because of click loss.

clusters only occur in languages that also have fricative-stop clusters. No fricative-stop clusters are attested in KBA languages, so the existence of stop-fricative and stop-stop clusters is unexpected. Thus, if the sound systems of KBA languages are subject to a cluster analysis, these languages violate cross-linguistic onset typologies. Cluster analyses must therefore overlook these typological patterns so as to bring KBA languages closer to cross-linguistic 'norms' for inventory size.

The second argument for a cluster analysis is that of inventory symmetries between clicks and non-clicks. Consider the consonant inventories of G|ui (Nakagawa, 2006) in Table 7 and Table 8 (on page 44). Nakagawa (2006)'s MCA[25] interprets basic clicks that are plain, voiced, aspirated, nasal or ejected as unitary phonemes. Other sound sequences are interpreted as clusters. This allows for simple segments to be characterised by standard cross-linguistic properties such as voice, aspiration, nasality, and ejection, without having to propose typologically rare properties (Naumann, 2016). Thus, in the MCA, delayed aspiration is interpreted as a cluster of plain click + [h], glottalised clicks are interpreted as plain click + [ʔ] clusters, and other clusters of click + dorsal segments are proposed. The argument of inventory symmetry is premised upon divisibility. That is, if a sound such as *!q* exists in a language's inventory, and *!* and *q* both exist as independent segments as well, *!q* may be a cluster of these two sounds. Indivisibility is a strong metric for assessing sound sequences that may be clusters (Riehl, 2008), and the fact that KBA language clusters seem to be divisible into existing segments is used as strong evidence for a cluster analysis. Furthermore, a cluster analysis can be used to predict more clusters that were previous unattested but are expected from the combinatorial patterns of the consonant inventory. Nakagawa (2006) predicted ejective clicks from a gap in the consonant inventory, and subsequently observed these clicks in G|ui, contrasting with glottalised clicks. Naumann (2016) attests to the same contrast in Taa (West !Xoon). This leads to the third argument for a cluster analysis – that clicks and non-clicks can be united within one representational system. This argument implies that the parallels between the click and non-click inventory are phonologically and phonetically salient. Thus, Güldemann (2001) argues that oral clicks behave phonologically and distributionally like egressive stops

[25] Nakagawa (2006)'s Radical Cluster Analysis is not addressed here and nor is Bradfield (2014)'s concurrency analysis.

and nasal clicks behave like nasal stops, so egressive and ingressive plosives should have symmetrical representations.

These arguments for a cluster analysis raise several complications:

First, the argument for a united inventory does not necessarily require a cluster analysis as a logical precondition. The parallels between clicks and non-clicks observed by Güldemann (2001) could plausibly be captured by features. The similarity between – for instance – *tx* and *!x* may not necessarily be that both *t* and *!* may combine with *x*. Instead, it is plausible that *tx* and *!x* are segments that are characterised by the same feature set that results in dorsal frication and are distinguished from one another by an airstream feature. The same can be said of predictions of previously-unattested consonants based on a unified symmetrical inventory. Thus, a cluster analysis cannot be taken to be axiomatic in this argument.

Second, predicting segments from patterns of clusters also requires constraints on what segments are allowed to cluster, and these constraints may cut across natural classes of sounds. Naumann (2016, p. 20) sets out these restrictions for Taa: in a bi-consonantal cluster, the first consonant (C1) position must be filled by "plain or voiced anterior egressive or ingressive stops" and the second consonant (C2) position must be filled by "uvular and glottal egressive obstruents". Furthermore, egressive stops in the C1 position may only be followed by uvular affricates or fricatives. There is no clear reason for clusters to be constrained in these ways. If *h* and *x* can participate in clusters, why not *s*? This is answered if one assumes that C2 is restricted to a Guttural class of sounds, which successfully groups uvulars and glottals to the exclusion of coronals. The more pressing question then is why *t* may cluster with *x* and *kx'* but not *q*. It is well-attested that fricatives and affricates do not form a natural class to the exclusion of plosives (Lin, 2011), so any restriction posited to account for this asymmetry in the inventory cuts across the class of stops (plosives and affricates). Moreover, the existence of a uvular stop series that is allowed to form clusters with clicks but not egressive stops is antithetical to an argument for clustering. Even within a unified consonantal system, clicks still need to be treated as a distinct subcategory of stops so that the clustering effects may be characterised. The problem of having to restrict egressive stops from clustering with uvular stops is solved by the idea of contouring airstreams within a segment (Miller, 2011). Clicks with a uvular plosive release are linguo-pulmonic contour segments. Egressive segments are already pulmonic, so cannot contour to produce a plosive release. A pulmonic-glottalic contour may occur, which would produce the ejective affricate. This is particularly troublesome for a cluster analysis, as it implies a sub-segmental nature of the uvular plosive click release.

Third, following from the argument above, there is the problem of over-prediction. Bennett (2020) gives a detailed overview of how the cluster analysis might predict clicks that do not exist from a pulmonic stop series as well as pulmonic stops that do not exist from click series when one tries to create a united consonant inventory. Bennett points out that in Nakagawa (2006)'s list of segments that cluster with clicks in G|ui – /χ/, /qχ'/, /q/, /ɢ/, /q^h/, /q'/, /ʔ/, and /h/ - only the first two occur in consonant sequences where C1 is a pulmonic stop. A unified consonant inventory may have correctly predicted a contrast between glottalised and ejective clicks in G|ui and !Xóõ, but it also incorrectly predicts a cluster series of pulmonic coronal stops plus various uvular and glottal segments.

Fourth, a cluster analysis should predict edge effects regarding syllable phonotactics. Given that consonant sequences only occur root-initially, there are no left-edge effects observable. One of the right-edge effects in some languages is the BVC. If a [+back] consonant must be followed by a [+back] vowel, the second consonant in a bi-consonantal cluster should be the sound that effects change on the vowel. Thus, the click in the C1 position should not be able to affect the vowel following C2, unless non-adjacent assimilation is proposed. If a glottalised click is a cluster of a plain click plus a glottal stop, and glottal stops do not trigger the BVC, then it is expected that all clicks with a glottal stop should be able to co-occur with front vowels. This is not true of glottalised alveolar clicks[26] in !Xóõ, N|uu, Ekoka !Xun, and Ju|'hoan. Conversely, one would expect palatal and dental clicks plus uvular plosives to cause a BVC effect in !Xóõ and N|uu, but this is not attested in my dataset.

Finally, the unification of an ingressive and egressive consonant inventory requires phonetic and phonological disparities between these consonants to be overlooked (Bennett, 2020). Bennett argues that the exercise of pairing clicks with non-clicks in a unified inventory leads one to minimize certain features of a sound in the pursuit of symmetricity. He uses the example of Güldemann (2001)'s inventory of Ju|'hoan, which groups nasal clicks with nasal stops and voiced nasal aspirated clicks with prevoiced aspirated stops. In this case, the nasality of the nasal aspirated click is overlooked (Bennett, 2020). Similarly, Bennett argues that the analysis of glottalised clicks and clicks with delayed aspiration as, respectively, plain click + [ʔ] and plain click + [h] conveniently ignores the nasal airflow of these sounds in favour of drawing

[26] The same goes for lateral clicks in these languages, with two exceptions over the entire Kx'a and Tuu database.

parallels between these clicks and pulmonic glottal segments. I suggest that the argument from inventory symmetry does the same. In N|uu, the posterior closure of the alveolar click is uvular and differs from that of the palatal click which extends up and back towards the end of the velum (Miller, 2010). For clicks with a uvular plosive release, the pulmonic release occurs at the same point of closure as the posterior click closure. That is, [!q] has the same posterior closure as [!] and the closure of [ǂq] is the same as that of [ǂ] (Miller, 2010). Thus, if these segments are both analysed as clusters of clicks + uvular plosives, the articulatory difference between the pulmonic releases of [!q] and [ǂq] are disregarded. Moreover, these clicks are expected to pattern together as uvulars with regard to the BVC, given that both of these consonant sequences are assumed to contain uvular segments. As previously stated, this prediction is not supported by my findings. Thus, analysing [!q] and [ǂq] as clusters containing the same uvular plosive overlooks important articulatory and phonological details.

6.2.1.2 The unit analysis

The unit analysis also posits some features that are not typologically typical. One of these is the contouring airstream feature. Clicks use an ingressive airstream mechanism, however, so it is to be expected that this airstream is represented in the phonologies of KBA language speakers. Thus, the typological 'anomaly' that is the airstream contour in some click phonemes is argued to be a natural extension of the existence of clicks themselves (Miller, 2011). However, the feature organisation of this proposal is unclear in previous literature (Miller, 2010, 2011; Miller et al., 2009; Miller, Namaseb, et al., 2007). What is referred to as a contour feature is not, strictly speaking, a *contour* within one feature node but a change from one distinct feature to another. That is, a [lingual airstream] feature changes to a [pulmonic airstream] or [glottalic airstream] feature. This makes segments with an airstream 'contour' into *complex* segments instead, in that these sounds have more than one airstream feature, making them analogous to complex segments with two Place features.

The unit analysis that proposes three airstream features must also account for certain theoretical complications that arise. The first is the representation of airstream features. If airstream features are binary, the question arises as to what [-lingual airstream] or [-pulmonic airstream] would mean phonologically. If airstream features are privative, such as [lingual airstream] and [pulmonic airstream], then segments must be allowed to have more than one airstream feature, making these sounds complex rather than contour segments. This is not the only complication, however. If a [lingual airstream] feature is proposed to account for sounds where airstream is initiated by the tongue, it should follow that all glottalized/ejective segments – within which airstream is initiated by the glottis – should be characterised by a [glottal airstream] feature. The [glottal airstream] feature would separate the Laryngeal features, as [+constricted glottis] would be subsumed by [glottal airstream] and [+spread glottis] would have to remain under the Laryngeal node. Reconfiguration of the commonly accepted feature hierarchy would be acceptable if it predicted the correct segments found in KBA languages. If three privative airstream features are posited – [lingual airstream], [glottal airstream], and [pulmonic airstream] – and attached directly to the Root node like other Manner features, this structure would correctly predict [pulmonic airstream] segments such as egressive stops, [lingual airstream] segments such as simple clicks, and [glottalic airstream] segments such as the glottal stop. It also predicts segments that are produced with a combination of airstreams: [pulmonic airstream] and [glottal airstream] segments, such as egressive ejective stops; [lingual airstream] and [glottal airstream] segments, such as glottalised clicks; [lingual airstream] and [pulmonic airstream] segments, such as clicks + *q* or *χ*; and [lingual airstream], [pulmonic airstream], and [glottal airstream] segments such as *!q’* and *!χ’*. This almost fully accounts for onsets in KBA languages. The only segments that cannot be captured by this system, as it stands, are egressive stops with a dorsal fricative or ejected dorsal affricate. A secondary articulation would need to be posited, which then causes clicks with a dorsal accompaniment and egressive stops with a dorsal accompaniment to require different feature geometries. It is also troubling that these discrete airstream segments would have to be ordered somehow, to prevent the prediction of – for example – [pulmonic airstream] and [lingual airstream] segments such as *x!. These complications do not disprove the unit analysis, but rather indicate that featural representation of complex onsets needs to be assessed further.

6.2.2 Individual languages

In this section, I discuss the phonological status of clusters/complex consonants in the six languages from which I collected data. I follow Riehl (2008)’s three-step process for cluster diagnosis whereby sound sequences are investigated regarding segmental inseparability, tautosyllabicity, and additional phonological evidence.

The second step in this process – tautosyllabicity – will not be addressed explicitly as all of the KBA languages only allow the sound sequences in question to occur root-initially, making every occurrence of a sound sequence tautosyllabic. ‘Additional phonological evidence’, as suggested by Gouskova and Stanton (2021) and Riehl (2008), may include information from sonority sequencing, distribution patterns of segments, inventory patterns, and O/E ratios. Given the problem of sonority sequencing that takes place in every language if a cluster analysis is used, significant phonological evidence for clusters must be present for this analysis to be accepted.

Assessment of clustering follows the MCA. The alveolar click is used to represent any click type in this section.

6.2.2.1 Khoekhoegowab

The Khoekhoegowab clicks – [!x^{h}], [ŋ̊!^{ʔ}], and [ŋ̊!^{h}] – can broadly be analysed as clusters of click + [kx^{h}], [ʔ], and [h], respectively, if nasal venting is relegated to a non-diagnostic phonetic phenomenon. The C2 position may only be filled by glottals or [kx^{h}], which cuts across the velar obstruent class by excluding [k] and [x] as segments that may cluster. This could be explained by assuming that a [!k] cluster yields a plain click, and a [!x] cluster has lost its contrast with [!x^{h}]. Thus, one cannot rule out separability of these sounds and must consider other phonological information.

If these sequences are clusters, they are all OO clusters and are either stop-fricative or stop-stop clusters. These patterns are typologically irregular. Furthermore, when glottalised clicks and clicks with delayed aspiration were assumed to be clusters, O/E ratios showed that these sounds occurred in the inventory between 13.03 and 38.77 times more than expected. O/E ratios for clicks with a velar aspirated/affricated release were even higher. Although not diagnostic, this indicates that clustering is unlikely. Additionally, a cluster analysis does not create a symmetrical onset consonant inventory as glottalised clicks and clicks with delayed aspiration have no pulmonic counterparts.

There are several loanwords in Khoekhoegowab that begin with clusters, so this may be evidence for the language permitting clusters. However, many loanwords also have clusters in the middle of words and violate other syllable restrictions in Khoekhoegowab. There are also some loanwords that have two pronunciations – one with a cluster and one where the cluster is broken up. A few loanwords have reduced the clusters in the origin language, but most are retained. Some loanwords with cluster onsets are given in the table below, from Haacke and Eiseb (2002).

Table 47. Loanwords with clusters in Khoekhoegowab

Khoekhoegowab	**Gloss and origin**[27]
brȍóxȍs ~ bȍróxȍs	bridge > Afrikaans *brug* [brʊx]
dȍrò ~ drȍò	dry up > Afrikaans *droog* [dru͡əx]
flii ~ fili	to fly > Afrikaans *flieg* [flix]
kı̋ní	knee > Afrikaans *knee* [kni]
klosters	cloister > Afrikaans *klooster* [klu͡əster]
plűú	plough > Afrikaans *ploeg* [plʉx]
pűrúkhòȅb	trousers > Afrikaans *broeke* [brʉkə]
skóli	school > Afrikaans *skool* [sku͡əl]

Data from loanwords is therefore inconclusive as some clusters are broken up and some are retained.

All things considered, there does not seem to be sufficient evidence for clustering in Khoekhoegowab.

6.2.2.2 Khwe

The sounds of Khwe that may be clusters or complex segments are all able to be divided into existing segments. In a cluster analysis, the first consonant of a cluster may be a click or a coronal egressive stop. The second consonant may be a velar, uvular, or glottal stop or fricative after clicks, but may only be a velar fricative after coronal egressive stops. The reason for this asymmetry is unclear in this analysis.

If these sounds are clusters, only OO clusters occur and are stop-stop or stop-fricative clusters. Thus, the Khwe inventory goes against typological norms if a cluster analysis is applied.

The set of stops that are palatalised or prenasalised are interesting as they are the result of click loss of the alveolar click series. If click loss is, as claimed by Nakagawa (2006) for Gǁana data, the process of cluster reduction by loss of the click consonant, then what remains should be the segment that clusters with a click. The set of stops that are the result of click loss seem to come from clicks that are not considered to be clusters. Moreover, to my knowledge [ŋg] exists in the inventory only through click loss and so the separability argument cannot be used to support a cluster analysis. Furthermore, the palatalisation is strange, implying that the combinatory pulmonic segment in click clusters is a palatalised velar stop. It is possible that the palatalisation is a strategy to distinguish between the original velar stops and the velar stops that arose from

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[27] The IPA forms of origin words are my own transcriptions. This is also the case for all subsequent tables that refer to loanwords.

click loss, or that palatalisation occurs to match some acoustic property of the alveolar click. It therefore seems that the process of click loss retains certain acoustic or perceptual features of clicks and that it is not straightforwardly a process of cluster deletion. Regarding the loss of clicks with dorsal accompaniments, Fehn (2019) reports that [!x] tends to be replaced by [x] and [!kx’] tends to be replaced by [k(x)’]. The replacement segment for [!q] is unattested. I have found two examples of words I believe to be cognate in Khwe and G|ui where a Khwe *q* corresponds to a G|ui *!q*, recorded in the table below, but I am not sure if this pattern extends any further than this. The G|ui data comes from Nakagawa, Sugawara, et al. (2023).

Table 48. Khwe-G|ui cognates showing a correspondence between [q] and [!q]

Khwe	**G|ui**	**Gloss**
qã̀ṹ	*!qàū̃*	cheetah
qárá	*!qárá*	split, break into pieces

The click loss data for clicks with dorsal accompaniments can be argued to be evidence for a cluster analysis. However, the inconsistencies between segments resulting from click loss of unitary segments and segments with dorsal elaboration weaken the usefulness of this data for the cluster analysis. If an alveolar click is replaced by [k^j], why is [!x] not replaced by [$k(^j)x$]? Also, if click loss is cluster reduction, one may be forced into a RCA to interpret the replacement of [^{ŋg}!] by [ŋg]. Again, a cluster analysis here might not be axiomatic – it is possible that a feature analysis could be as effective as a cluster analysis for accounting for click loss data. The data from click loss seems to be inconclusive.

Many loanwords are noted in the Khwe dictionary (König & Heine, 2008). A lot are from Mbukushu, a Bantu language spoken around the same area. Mbukushu has already broken up the clusters in English or Afrikaans loanwords, so these words cannot tell us much about cluster reduction in Khwe. The words that are marked as being loaned directly from English or Afrikaans show an inconsistent pattern of cluster reduction. Some loanwords onsets that are clusters are broken up and other are retained. A selection of loanwords is included in the following table. The words are reproduced as written in the dictionary, which uses *c* to represent an alveolar/post-alveolar/palatal fricative [ʃ].

Table 49. Loanwords with cluster onsets in Khwe

Khwe	**Gloss and origin**
cìtícìnì	police station > English
ctórì	story > Afrikaans *storie* [stu͡əri]
cìtírì	send > Afrikaans *stuur* [stʉ:r]
cpíkìrì	nail > Afrikaans *spiker* [spe͡ikər]
ctrat	street > Afrikaans *straat* [strɑ:t]
drí	three > Afrikaans *three* [dri]
Fránc(i)	France > English
fùrútà	fruit > English
p(è)réndè	picture > Afrikaans *prent* [prent]
plactik	plastic bag > Afrikaans *plastiek* [plɐstik]
p(ò)ròfítà	prophet > Afrikaans *profeet* [profi͡ət]
xrúntè	vegetables > Afrikaans *groente* [xrʉntə]

Thus, the reduction of clusters in loanwords does take place in some cases but not in others. Evidence from loanwords is therefore inconclusive.

The O/E ratios for clusters of clicks or dental stops with a dorsal fricative are high, with far more observed co-occurrences than expected. Similarly high O/E ratios occur for clicks with an ejective dorsal affricate and clicks with a uvular stop. O/E ratios show that these sound sequences are occurring between 5.14 and 27.66 times more frequently than is expected.

I do not think that there is sufficient evidence in Khwe to support a cluster analysis.

6.2.2.3 !Xóõ

Clicks in !Xóõ seem to be remarkably well-matched to the pulmonic uvular series. There is also some symmetry between nasal clicks and nasal stops, with both having a plain and preglottalised series. There are no clear egressive counterparts for the glottalised click and the click with delayed aspiration, unless the glottal obstruents are counted which again requires a reduction of phonetic/phonological detail.

All possible clusters are highly typologically marked, as they are OO clusters that are stop-fricative or stop-stop sequences, with no fricative-stop clusters allowed.

There are eight loanwords marked in the !Xóõ dictionary that violate the onset restrictions of the language. All of these have plosive-liquid onsets and seem to be variable, with some having variant forms that break up the cluster. The few OO loanwords that do occur are always broken up. A selection of loanwords are represented below, from Traill (1994).

Table 50. Loanwords with clustered onsets in !Xóõ

!Xóõ	Gloss and origin
brìka	brake (n) > English
bùrukò	trousers > Afrikaans *broek* [brʉk]
dràmu	drum > English
fúlu	flu > English
grèi dāra	grader > English
kòpe lèe	button > Afrikaans *knoppie* [knopi]
sikwélè	school > Setswana *sekole* [sekole]
sìtùlu	chair > Afrikaans *stoel* [stul]
sî māu sú	small goods trader > Afrikaans *smous* [smo͡ʉs]
tìratà ~ tràatà	wire > Afrikaans *draad* [drɑ:t]
tóro ŋkòo	jail > Afrikaans *tronk* [tronk]
tràŋ kàa	trunk > English
xāla síi	bottle > Afrikaans *glas* [xlas][28]
xàro	spade > Afrikaans *graaf* [xrɑ:f]

The way in which loanwords are incorporated into the inventory are inconsistent, although it seems that English loanwords are more likely to retain their plosive-liquid onsets than Afrikaans loanwords. However, all OO onsets are split up, so there seems to be a dispreferrence for clustered OO onsets in !Xóõ.

Also striking about the !Xóõ inventory is the large range in frequencies for different onsets. Many of the complex sound sequences in question are marginal, and there seems to be a high degree of semantic repetition across similar word-forms in the lexical database. That is, there are many words that mean the same thing and have similar phonetic forms. This is especially apparent for the coronal series. A few of these are listed below, from Traill (1994).

Table 51. !Xóõ words with similar onsets and the same meanings

!Xóõ	Gloss
txóna ~ dtxóna	bowels with wet green faecal matter
dtxàa ~ dtshàle	to split
dthàba ~ dt'kx'àba	flutter
dthàna ~ dtxába	lean, emaciated

In the table, the items with variation between aspiration and dorsal frication/ejective affrication are of particular interest. This is hard to capture within a cluster analysis, as one is forced to posit a connection between aspiration and segmental *kx'* or *x*. I think that it is more likely that these onsets in !Xóõ are complex unitary phonemes that have similar feature representations,

[28] I assume that this borrowing is from the Afrikaans word for 'glass' rather than 'bottle' (Afrikaans: *bottel*).

and that small inconsistencies between laryngeal features are not enough to stop the word from being understood or correctly perceived. There are a lot of ideophones that show these variations, so it is possible that maintaining an exact feature contrast for ideophones is not necessary. These correspondences do, however, cast doubt on boundaries of the phonemic categories of !Xóõ. More research is needed here, but I continue to follow Traill (1985) in his assertion that these onsets are contrastive.

There is also an uneven frequency distribution within the clicks. Plain oral and nasal clicks are more common than other types of clicks. O/E ratios, however, show that clicks with dorsal accompaniments are still occurring far more frequently than would be expected if they were clusters of individual segments, occurring between 5.08 and 80.95 times more than expected. Thus, it is more likely that the !Xóõ onsets in question are complex segments rather than clusters of segments.

6.2.2.4 N|uu

Almost all complex/clustered onsets in N|uu are – roughly – divisible, if one accepts the glottal stop to be phonemic. One complex click is not divisible: the click with aspirated uvular plosive has no corresponding egressive segment[29]. Moreover, these clicks are not marginal in the onset inventory. It stands to reason that a language that lost [q^h] from its consonant inventory – as I assume it has, given the existence of the segment in !Xóõ – would also lose this sound from clusters. The indivisibility of one complex segment alone is enough to categorise this and similar sounds, by analogy, as complex phonemes. More phonological evidence will be considered, however.

If the onsets in N|uu are clusters, then all onsets are OO and are stop-fricative or stop-stop clusters, which is typologically irregular. Loanwords in N|uu that begin with clusters may include OO clusters, such as [st] or [sk], and allow obstruent-liquid clusters. However, I do not think that loanwords in N|uu are a useful source of information about N|uu phonology as N|uu is spoken within a community whose first and dominant language is Afrikaans (Brenzinger & Shah, 2019; Miller et al., 2009). Nama is also spoken in these communities (Sands & Jones,

[29] I assume that a cluster analysis would pair the devoiced uvular plosive [ɢ̊] with the voiced click with a uvular plosive accompaniment, so do not address that segment here.

2022).It is beyond the scope of this paper to discuss the complexities that arise from such a language context, such as multiple or changing phonologies in a moribund language.

Notable in the frequency table is that [q] occurs more infrequently than clicks with a uvular plosive accompaniment. This is similar to, but less extreme than, the case of clicks with an aspirated uvular plosive that have no egressive counterpart. The difference in frequency between clicks with uvular plosive accompaniments and egressive uvular segments is reflected in the extremely high O/E ratios for clicks + [q], which range between 36.71 and 54.57. The O/E ratios for clicks with uvular fricative/ejective affricate releases is also high, with far more observed co-occurrences than expected. Thus, the likelihood of sound sequences in N|uu being clusters is very low.

6.2.2.5 Ju|'hoan

Most sound sequences that may be analysed as clusters are divisible into attested segments (again accepting the glottal stop as phonemic), but not all. Particularly notable is that the segments *[dts]/[dz] and *[dtʃ]/[dʒ] do not exist in the inventory, so Dickens (1994)'s *dzx* and *djx* onsets have no clear C1 correspondence. These segments are, therefore, indivisible, suggesting that the rest of sound sequences in question may be analysed as units as well.

All possible clusters would be OO clusters in Ju|'hoan, and would be stop-fricative or stop-stop clusters.

The two strident coronal stop series do not include *[dtskχ'] or *[dtʃkχ'], and the non-strident stops do not occur with ejection, both of which create asymmetries in the inventory. Many of the other segments within these series are marginal, however, so Ju|'hoan may have just lost these sounds over time.

There is also a big difference in the frequency of onsets. In general, clicks that are (pre)voiced are far less common than their voiceless counterpart. This is especially true of clicks with a dorsal accompaniment. This pattern would be unexpected if these sounds are clusters: if [!χ] is a cluster of [!] + [χ] and these sounds may freely combine, the same should be true of [ᶢ!χ] if it is a cluster of [ᶢ!] + [χ]. That is, there is no phonological reason for [χ] to freely cluster with plain clicks and to cluster infrequently with voiced clicks. It is possible that voiced clicks with accompaniments are articulatorily more complex than plain clicks, and added articulatory complexity results in minor feature contrasts being reduced if the word is still able to be parsed by the listener.

Miller-Ockhuizen (2003) demonstrates a strong avoidance of clusters in the assimilation of loanwords. She lists a few examples, reproduced here: *tóró* meaning ‘wedding’, from the Afrikaans *trou*; *tȁʱrà* meaning ‘wire’, from the Afrikaans *draat*; and *tòrà* meaning ‘store’, from English[30].

O/E ratios for stops with dorsal fricatives and ejective dorsal affricates are high, showing that these segments are combining far more frequently than would be expected if the sound sequences in question are clusters. The same is true of delayed aspirated clicks if analysed as a cluster of a click + *h*.

Thus, there seems to be insufficient evidence for complex segments in Ju|’hoan to be classified as clusters.

6.2.2.6 Ekoka !Xun

In Ekoka !Xun, all sound sequences that can be analysed as clusters are divisible (if the glottal stop is included).

The clusters that are produced from such an analysis are OO clusters, made up of two stops or a stop followed by a fricative.

The same unequal frequencies as Ju|’hoan exist for (pre)voiced segments in Ekoka !Xun. Many of these sounds are marginal, with marked differences between the number of plain voiced segments and voiced segments with laryngeal elaboration or dorsal accompaniments. Like in Ju|’hoan, I think that the simplest explanation is reduction of feature contrasts because of articulatory complexity.

There are very few loanwords recorded in the dictionary of Northwestern !Xun (König & Heine, 2008). One that is recorded by König and Heine is *bélé*, meaning ‘bread’, loaned from English. Thus, loanwords might be harder to identify if they are assimilated into the lexicon and are subject to syllable phonotactics that break up onset clusters.

[30] Unfortunately I was not able to compare this data to the forms in Dickens (1994) as I only had temporary access to a hardcopy of the dictionary.

O/E ratios yielded high outputs for stops with dorsal accompaniments if these sounds were analysed as clusters, with these sound sequences occurring between 6.63 and 39.78 times more frequently than expected.

Evidence for clustering in Ekoka !Xun onsets seems to be lacking.

6.2.2.7 Section summary

In every language included in this study, the O/E ratios for onsets assumed to be clusters are high. An O/E ratio of one would show that the onsets are occurring at an expected rate in comparison to the frequencies of their constituent segments. However, the O/E ratios for these onsets were consistently far higher. Given this finding, and additional information from the onset inventories, phonological patterning, and indivisibility of certain onsets, the cluster analysis seems inadequate in the representation of the onsets. Thus, in all six KBA languages included in this study, root-initial onsets with multiple articulations are interpreted as complex segments rather than clusters.

6.3 Proposal for feature representation of complex onsets in KBA languages

If complex onsets in KBA languages are not considered to be clusters, an alternative representation of equal explanatory power must be suggested. This section explores an alternative representational theory that considers all (non-borrowed) complex onsets in KBA languages as unitary segments. The formal representations for sounds in these languages mentioned in section 3.2 are briefly discussed. A new feature geometry structure is then proposed.

6.3.1 Complications within previous analyses

Previous formal analyses of KBA languages have often focussed on only certain aspects of the phonologies of these languages, as bounded by the scope of their papers. The problem that arises in this situation, however, is that the representational theories posited are not always capable of being extended to account for other aspects of the phonologies. This subsection covers the difficulties regarding Place of Articulation features for clicks and complex onsets, as well as the lack of attention to laryngeal features that may be poignant in the specification of these onsets.

6.3.1.1 One or two Places of Articulation?

Generally, analyses of clicks decide between two logical possibilities for their representation in feature geometry: (i) clicks have one Place of Articulation, dividing click types into Labial, Coronal, and Dorsal clicks, or (ii) clicks have two Places of Articulation, one Dorsal and the other Labial or Coronal. The first includes arguments that propose one primary Place of articulation and relegate the other closure to a secondary articulation.

One Place of Articulation is argued for by authors such as Miller, Brugman, et al. (2007), Halle (1995), and Bennett (2014). Various implications follow from the first option. In this analysis, clicks have one closure that is not phonologically active. This means that the four click types articulated with the tongue blade and tip – [|, !, ‖, ǂ] – are not necessarily all Coronal. Halle (1995) argues that the dental and palatal clicks are Coronal, as they do not participate in the BVC, and the alveolar and lateral clicks are Dorsal, as they do show BVC effects. Bilabial clicks are Labial. This analysis also requires a feature that specifies clicks from other consonants. Therefore, a [suction] or [click] feature must be posited (Chomsky & Halle, 1968; Traill, 1985) or an airstream feature such as [lingual] must be incorporated (Miller, Brugman, et al., 2007; Miller et al., 2009). An analysis such as Halle (1995)'s features do not account for the patterning of the bilabial clicks with the other 'Dorsal' clicks regarding the BVC in some languages. This type of analysis also requires the differences in the coronal articulations of the Dorsal clicks to be phonetic and not phonological.

Clements and Hume (1995) imply that all clicks have a [dorsal] specification and that the BVC is caused by a spreading of that [dorsal] feature to the following vowel. Extrapolating from this statement, clicks are assumed to have a primary C-Place Articulation and are secondarily specified for a V-Place articulation. This can only account for plain clicks and not for clicks with dorsal accompaniments. One could assume, using a Clements and Hume (1995)-style model, that the V-Place node could be used to specify the dorsal accompaniments of clicks and egressive stops. This system has three key flaws. The first is that a [continuant] feature would have to be specified under the V-Place node so that the representation can account for dorsal fricative and dorsal plosive accompaniments on clicks. Degree of closure features cannot be specified for individual Places of Articulation (Sagey, 1986). The second flaw is related to the first: this system cannot predict the asymmetry between the dorsal accompaniments allowed with clicks and those allowed on pulmonic stops. Thus, arbitrary restrictions will have to be proposed so that egressive stops are not allowed a uvular plosive accompaniment. The third flaw is the issue of overprediction. The model also seems to imply that consonants should be able to be specified for a secondary Labial or Coronal place, which would far overpredict the number of consonants allowed to occur.

This leads one to consider the second logical possibility for the analysis of clicks: that clicks have two Places of Articulation. This is argued for by Sagey (1986), Nakagawa (2006), and Traill (1985). Traill argues that there is no evidence for the posterior closure and release of a click being phonologically secondary. Thus, he argues against analysing clicks as consonants with 'extreme velarization', as Chomsky and Halle (1968) did, and as is implied by the Clements and Hume (1995)-style model. If both the anterior and posterior closures of clicks are equally phonologically salient, an analysis that follows Clements and Hume (1995) in using a V-Place feature to capture the posterior click closure is not appropriate.

Sagey (1986)'s treatment of all clicks as complex segments is useful. It efficiently captures the contrasts between Nama/Korana segments and phonologically represents both closures in a click. Complications arise in her analysis of !Xóõ and !Xun segments, where the double Place of Articulation specification of clicks and egressive coronal stops with a dorsal accompaniment results in the same feature specification of [tx] and [ǂ], and [tsx] and [ǂx]. Sagey posits a major articulator feature to distinguish them, which 'points' to the Place of Articulation that is phonologically primary. All clicks are deemed primarily Dorsal, and all coronal egressives are deemed Coronal. The 'minor' Place of Articulation feature yields predictable phonetic affrication and so allows the major Place of Articulation to use the [continuant] feature. This results in the [continuant] feature being used to distinguish [t] from [ts] and [ǂ] from [ǂx]. The trouble with this analysis is that the dorsal fricative accompaniment is thus phonologically different for clicks and non-clicks. Additionally, a 'pointing' mechanism of phonological primary-ness is theoretically circular, requiring the phonology to 'know' which Place of Articulation is more primary before indicating said primary-ness. Sagey argued that the Major/Minor feature could replace [suction], but I find the [suction] feature to be less theoretically complicated.

Ultimately, any formal representation of the onset inventory of KBA language should aim to use the same set of features to characterise the click and non-click sounds, to account for the BVC (if it is active in the relevant language), to capture the phonological aspects of both click closures, to reflect the symmetry between the dorsal fricative/ejective affricate accompaniments on clicks and egressive stops, and to account for the asymmetry between click and non-click consonants regarding uvular plosive accompaniments.

6.3.1.2 The need for an expanded set of Laryngeal Tract features

One of the shortcomings of almost all previous feature analyses of clicks is the lack of attention given to guttural sounds. In general, the accompaniment that has been referred to in this paper as a 'dorsal fricative' – *x* or *χ* – has been called a velar fricative accompaniment or, occasionally, a uvular fricative accompaniment. The *kx'* accompaniment is mostly referred to as an ejected velar affricate/fricative. The *q* accompaniments have tended to be labelled as uvular. This nomenclature has resulted in these sounds being analysed simply as Dorsal, overlooking the fact that – at least in some languages such as !Xóõ – some of these sounds are uvular-pharyngeal (Traill, 1985). 'Pharyngeality' is largely unaccounted for in the representation of sounds in KBA languages. One exception is Amanda Miller's analysis of certain Ju|'hoan phonemes as epiglottal (Miller-Ockhuizen, 2003). As is evident from the phonetic/phonological descriptions of sounds mentioned in section 5.2, there are a number of consonants in KBA languages that seem to have a post-uvular component. Vowels in Kx'a and Tuu languages may be pharyngealised or epiglottalised (Dickens, 1994; König & Heine, 2008; Miller, Brugman, et al., 2007; Traill, 1994), further indicating that pharyngeality is part of the languages' broader phonologies. Traill (1985) describes *q, x,* and complex stops involving these sounds as being produced with pharyngeal narrowing. Thus, I believe that any featural representation of these languages needs to include additional specification within the Laryngeal Tract.

6.3.2 A new feature geometry

Given the complications and lacunae discussed in the previous sections, a new feature geometry analysis must be proposed. The diagram below represents the proposed feature geometry for Kx'a and Tuu languages. It is also applicable to Khoe-Kwadi languages with larger inventories, such as G|ui, but its usefulness for languages such as Khoekhoegowab is limited. Khoekhoegowab and Khwe do not show the same distributional constraints as the Tuu and Kx'a languages. Furthermore, not enough information about phonotactic patterns in the Khoe-Kwadi languages was ascertained from the data collected during this study, so a feature geometry representation of these languages would have no empirical foundation. For these reasons, these languages are not considered in the following feature geometry.

The structure is an Articulator-Based feature geometry premised upon Esling et al. (2019)'s division of the vocal tract into an Oral and Laryngeal Tract, and drawing from Moisik et al.

(2012) and Vaux (1999)[31]. An overview of the representational choices made in this structure is given in the paragraphs that follow.

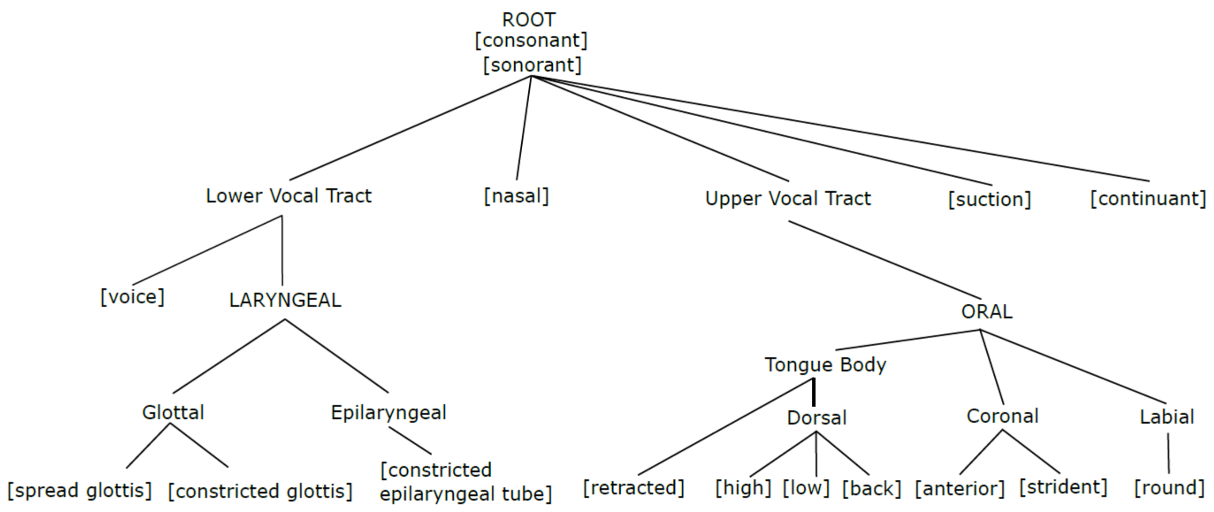

Figure 11. Proposed feature geometry for KBA languages

A [+suction] feature allows a segment to be specified for two Oral Places of Articulation. Pulmonic segments lack this feature and are specified for one Oral Place of Articulation. The [continuant] feature is used to distinguish fricatives from plosives. The [nasal] feature is used to specify nasal segments. I include nasal clicks and clicks with nasal venting in this category, following Naumann (2016, p. 15), who categorises "all sounds produced with complete oral closure and an obligatory nasal airflow" as nasal.

6.3.2.1 The Upper Vocal Tract node

The Oral node specifies sounds for Place features. Stops may occur at the Dorsal, Coronal, or Labial Place, with clicks having two Places of Articulation. The 'Tongue Body' node is superordinate to Dorsal and [retracted], following Moisik et al. (2012). The dorsum is not the only posterior section of the tongue that is articulatorily and phonologically active in the Oral Tract. Thus, 'Tongue Body' subsumes the dorsum of the tongue, the back of the tongue, and the upper part of the tongue root. The tongue body and upper root act as an independent articulator within the Oral Tract, as opposed to the movement of the tongue root in the Laryngeal Tract

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[31] Where Moisik et al. use 'PHARYNGEAL', I use 'LARYNGEAL', in keeping with Esling (2005)'s definition of the Laryngeal Vocal Tract. Where Moisik et al. use 'Epilaryngeal Tube', I use 'Epilaryngeal'. This is for the sake of efficacy and simplicity. I do not follow Moisik et al. (2012) in proposing a dually-linked [retracted] node.

within which retraction happens through the mechanism of the epilaryngeal constrictor. This is the reason for [retracted] being placed within the Oral Tract.

[Dorsal] characterises Dorsal consonants such as velar stops, uvular stops, the uvular-pharyngeal fricative, and all clicks. All clicks and other dorsal plosives are considered [+high, +back]. In the Tuu and Kx'a languages, I propose that the lowering or 'backing' of front vowels after certain consonants is less about 'back-ness' than retraction. Thus, I suggest that the bilabial, lateral, and alveolar clicks are [+retracted], and the palatal and dental clicks are not. Egressive uvular stops are also specified for [+retracted]. The uvular fricative has a secondary [+cet] feature.

[Coronal] characterises dental, alveolar, and palatal segments. An [anterior] feature separates sounds broadly into [+anterior] denti-alveolars and [-anterior] postalveolar-palatals. The *t*-series is distinguished from the *ts*-series by a [+strident] feature, applicable to the latter. Thus, the [+strident] feature specifies egressive pulmonic 'affricates' such as [ts] and [tʃ]. This avoids the use of contouring [continuant] features for affricates as these quickly complicate the machinery of a representational system that allows double Place specification. The anterior closure of clicks is not the focus of this thesis, so is not deeply interrogated.

[Labial] characterises bilabial clicks, plosives, and bilabial nasals. The Labial set of consonants in Tuu is impoverished, and most Labial consonants occur marginally (Miller, 2010). The same is true of Kx'a languages. Thus, a full set of Labial consonants akin to the *t*-series is not expected.

6.3.2.2 The Lower Vocal Tract node

Crucial to this proposal is an expanded Laryngeal Tract node. This accounts for the differences in vowel phonation and also for the Guttural OCP or Single Glottal Constraint effects observed by Miller-Ockhuizen (2003) and Traill (1985), respectively. The Lower Vocal Tract (LVT) Node has three daughter nodes: [voice], [Glottal], and [Epilaryngeal]. The latter houses the dependent node [cet], which is active in sounds with pharyngeal retraction of the tongue root and constriction of the epilaryngeal space.

For the sake of precision of language, I use the term 'Epilaryngeal' where 'Pharyngeal' or 'Guttural' has previously been used, following Moisik et al. (2012). 'Epilaryngeal' has a specific reference point, denoting the constrictor mechanism in the laryngeal tract that includes the epiglottis, arytenoid cartilages, aryepiglottic folds, ventricular folds, but does not include the vocal folds. ‘Guttural’ is not used as it may imply the inclusion of uvulars in this grouping. ‘Pharyngeal’ is not used as it is too nebulous. ‘Pharyngeal’ has been used by Miller-Ockhuizen (2003) to describe alveolar and lateral clicks, and has also been used by Miller et al. (2009) in the description of the posterior closure of palatal clicks as ‘uvulo-pharyngeal’. Thus, ‘Pharyngeal’ encompasses the oropharynx and the laryngopharynx, which is too broad for the purpose of this project.

The [voice] node is considered separate from the other Laryngeal features as it does not participate in the Single Glottal Constraint or the Guttural OCP. All stops[32] may be specified for all LVT features: [±voice] specifies the voicing of a segment; [+spread glottis] specifies aspiration; [-constricted glottis] specifies ejection or glottalisation; and [+cet)] specifies epilaryngeal constriction and subsequent retraction of the tongue root, as in [χ], phonemes with [χ] and [(k/q)χ’] releases, and pharyngealized or epiglottalised vowels. The combination of [+constricted glottis] and [+cet] yields an ejective (af)fricated release such as the accompaniment [(k/q)χ’].

6.3.2.3 Evidence for the proposed feature geometry structure

Evidence for this structure is taken from phonological constraints such as the BVC and the Guttural OCP or Single Glottal Constraint, and is explained in the following paragraphs, using examples from the surveyed Kx’a and Tuu languages (predominantly from !Xóõ and Ekoka !Xun).

Regarding the Oral Tract features, the crucial divergence from a typical feature geometry structure is the Tongue Body node with a dependent [retracted] feature. The [retracted] feature cannot be a Laryngeal feature, as it does not pattern with other Laryngeal features in restricting the phonation type of the following vowel. The Tongue Body node is also the locus of the BVC, where [+retracted] segments prohibit following vowels. Non-retracted dorsal segments may show a weaker dispreference for front vowels, as demonstrated in !Xóõ, Ekoka !Xun, and Ju|’hoan. N|uu does not show the latter dispreference.

Proposing that only bilabial, alveolar, and lateral clicks are [+retracted] implies that the palatal and dental clicks with a ‘uvular’ plosive accompaniment should not be subject to the BVC. As

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32 Fricatives, nasals, and sonorants may restricted in their specification of Lower Vocal Tract features.

clicks with a uvular plosive accompaniment do not occur in Ju|'hoan and Ekoka !Xun, only evidence from N|uu and !Xóõ is considered here. In !Xóõ: *ʘq*, *ʘqh*, *gʘqh*, *ʘɢ, ʘq'*, *!q, !ɢ, !qh, g!qh, ɢ!qh, !q', ǁq, ǁɢ, ǁqh, gǁqh,* and *ǁq'* are never followed by front vowels, but some front vowels co-occur with the equivalent clicks in the palatal and dental click series. The same tends to hold true for N|uu, although the occasional front vowel is recorded after a few alveolar and lateral clicks with a uvular plosive accompaniment. This confirms that bilabial, alveolar, and lateral clicks are [+retracted] and palatal and dental clicks are not. It also confirms that the 'uvular' plosive accompaniment on the palatal and dental clicks is not phonologically uvular or [+retracted]. I suggest, based on a similar proposal by Miller, Brugman, et al. (2007), that plain clicks and clicks with a uvular plosive component are distinguished by an airstream contour feature. Miller et al. suggest that the latter have a contour from lingual airstream to pulmonic airstream. As mentioned before, this would entail proposing that clicks with a uvular plosive component are complex segments in that they have two airstream features, so for the sake of simplicity, I propose that a [suction] feature is represented as a dependent feature of the Root node, and that this feature may contour. Thus, plain clicks are considered to have a [+suction] feature and clicks with a uvular plosive accompaniment are considered to contour from a [+suction] manner feature to a [-suction] feature. This feature is allowed to contour in Tuu languages but not in Kx'a languages, which explains why clicks with a uvular plosive accompaniment are not attested.

The choice of Coronal features is important in the proposal of a feature geometry but is not a central topic in this thesis. Thus, the Coronal features are briefly discussed but require further analysis in future studies. Traill (1985) is careful to note that, at least in !Xóõ, no phonological difference should be made between the dental and post-dental or alveolar place, as consonants articulated at these places tend not to maintain a place distinction and vary in their place of articulation. This is true of clicks with a coronal anterior closure as well. Thus, Traill argues, !Xóõ has four phonological Places of Articulation: Labial, Dental-post-dental, Velar, and Uvular. This makes the anterior constriction of all clicks (except the bilabial click) Coronal. As the posterior constriction of the four Coronal clicks is enough to distinguish the alveolar and lateral clicks from the palatal and dental ones, only one more feature is needed to capture all contrasts. Traill (1985) is reluctant to suggest a [lateral] feature for the lateral click, as [lateral] has no other application in !Xóõ, given that the only other 'lateral' segment, [l], is an allophone of [t]. Features such as [anterior] and [distributed] are not particularly useful because of the variation with which the anterior closure of clicks is formed. It is possible to suggest a [strident] feature, classifying the dental and lateral clicks as [+strident] and the palatal and alveolar clicks as [-strident]. This parallels Traill (1985)'s suggested [friction] feature to account for the differences between noisy and abrupt clicks. Traill further describes *s* and *ts* as consistently post-dental, so the [strident] feature could be used to characterise the *ts*-series, analysing this as a strident stop rather than an affricate that has a contour of [continuant] features. However, it seems that [+strident] segments such as [ts], [tʃ], [s], and [ʃ] may cause vowel raising or fronting in some languages, such as N|uu and Ju|'hoan. Non-strident Coronal stops do not seem to raise or front vowels to the same extent. Because the alveolar lateral click does not cause vowel raising or fronting, it must be assumed that this click type is not specified for [+strident], even though this feature would be useful in the division of click types. Alternatively, it is possible to represent Coronal clicks using [apical] and [laminal] features. This feature is not useful in the distinction of egressive stops, however. Although Traill (1985) argues that minor place distinctions between clicks are not phonological, the non-click consonant inventories of these languages suggest that there is at least a distinction between the denti-alveolar region and the palatal region. Ju|'hoan has two alveo-palatal affricate series, [ts] and [tʃ], which are only differentiated by their Place of Articulation. Laminality is not useful in the distinction of these sounds, which is why I suggest that the Coronal node has [anterior] and [strident] dependent features. One could also use Nakagawa (2006)'s suggested Coronal dependent features, [palatal] and [apical]. This may more accurately account for the anterior closure of clicks and is easily substitutable into my suggested model, but further investigation of this topic is beyond the scope of the paper.

The structure of the Laryngeal Tract is motivated by vowel phonation constraints. Observations about these co-occurrence restrictions are laid out in Chapter 5. As previously noted, [voice] does not participate in this restriction, so is separated from other Laryngeal features in the feature geometry. The grouping of Glottal and Epilaryngeal features under a Laryngeal node is motivated by patterns of vowel phonation type restriction. For !Xóõ stops (including oral clicks and affricates) and Ekoka !Xun stops and fricatives, any stop consonant that is glottalised, aspirated, or has a uvular fricative component may not be followed by any vowel that is pharyngealised/epiglottalised, glottalised, or breathy. Thus, the Laryngeal features must be grouped as they all participate in the same constraint. This patterning also implies that the same Laryngeal features specifying consonants are also used to specify vowels. !Xóõ fricatives participate in a weaker version of this constraint, which allows one to isolate the effects of the [cet] and [+spread glottis] features. In !Xóõ, the voiceless fricative [s] may not be followed by breathy vowels, but it may be followed by pharyngealised or glottalised vowels. This indicates that the same Laryngeal feature is present on breathy vowels and on [s]. Vaux (1998) argues that voiceless fricatives are [+spread glottis], and this feature specification is consistent with the patterns observed. The voiceless fricative [χ] may not be followed by breathy, strident, or pharyngealised vowels, but may be followed by glottalised vowels. Thus, [χ] must have a [+spread glottis] feature as well as a feature that is shared with pharyngealised vowels. This is my suggested [cet] feature. It is crucial to note that [q] may be followed by any vowel phonation type, so [χ] must be specified for some LVT feature that is not specified for [q]. A difference in the behaviour of uvular plosives and fricatives is attested in other languages (McCarthy, 1988; Rose, 1996). Thus, it is not the uvular nature of [χ] that is causing the co-occurrence restriction, but the Epilaryngeal feature [+cet]. !Xoo [h] is allowed to co-occur with breathy vowels, thus not patterning with other voiceless fricatives as [+spread glottis]. I follow Ladefoged (1990) in analysing !Xóõ [h] as a voiceless approximant rather than a glottal fricative. This removes [h] from the class of obstruents and so excludes it from the restrictions on obstruent-vowel co-occurrences. In Ekoka !Xun, [ɦ] patterns with the other oral obstruents in prohibiting the co-occurrence of laryngeal vowel phonation types. Thus, I assume that aspirated consonants, breathy vowels, and voiceless fricatives are specified for [+spread glottis], and [χ] is further specified for [+cet]. Segments with a uvular fricative accompaniment do not co-occur with laryngeal vowel phonation types, so the same [+cet] feature present on [χ] must be present on these sounds too. In place of Traill (1985)'s 'Single Glottal Constraint', I therefore propose a 'Single Laryngeal Constraint', which states that vowels with any phonation type that involves the altering of a modal vowel within the Laryngeal Vocal Tract are not permitted to co-occur with oral obstruents that are specified for Laryngeal features. !Xóõ fricatives are subject to a pared-down version of this constraint, which prohibits the fricatives from being followed by vowels with the same specific Laryngeal feature.

Crucially, this constraint does not apply to voiced nasal segments, as nasal obstruents in these languages have different behavioural patterns to oral obstruents. Voiced nasal segments include pulmonic nasals as well as voiced nasal clicks and preglottalised nasal clicks, as preglottalised nasal clicks freely co-occur with Laryngeal vowel phonation types and thus do not pattern with oral obstruents in this regard. Clicks with nasal venting tend to pattern with oral obstruents in prohibiting laryngeal vowel phonation types from following them, but do not take dorsal accompaniments, so pattern inconsistently with both voiced nasals and oral obstruents. A further investigation of these sounds is beyond the scope of this paper.

6.3.2.4 Advantages of the model

This model accounts for some of the supposed ‘asymmetries’ of the Tuu and Kx’a onset inventories. Crucially, the proposed feature geometry predicts uvular plosive accompaniments to occur only on clicks, not on pulmonic stops. This is not predicted by a cluster analysis, within which this systematic gap in the inventory must be dismissed as an accidental gap or controlled for by a co-occurrence restriction that applies to pulmonic stops and not clicks. In my proposal, the [suction] contour has the phonetic effect of a uvular plosive release, and this is naturally unavailable to pulmonic segments. I also propose that the [suction] feature may not contour in Ju|’hoan and Ekoka !Xun, which is why these languages do not have clicks with a uvular plosive release. This avoids the need to draw arbitrary restrictions as to which uvular segments may participate in clusters. It also avoids the specification and restriction of [continuant] features, which quickly become complicated in a proposal that posits airstream contours, as linguo-pulmonic segments in the Kx’a languages are forced to have a contouring [continuant] feature.

My proposal also effectively accounts for the behaviour of egressive Coronal stops with dorsal fricative/ejective affricate releases. Both pulmonic stops and clicks are predicted to occur with *x* and *kx’* as these accompaniments are specified by dependent features of the Laryngeal node, rather than a second Place of Articulation feature. This means that the dorsal fricative/ejective affricate accompaniment has the same specification for clicks and non-clicks.

This analysis further accounts for the symmetries between ‘back’ clicks ([ʘ], [!], and [ǁ]) and non-‘back’ clicks ([|] and [ǂ]). With both places of closure being phonologically specified, the meaningful differences between anterior articulations are captured, as well as the meaningful similarities between the posterior closures. The specification of clicks using one Place of Articulation would simplify the features needed to distinguish between click types, but would necessarily imply that the place of posterior release is phonological for sounds such as [!] and [!q], but phonetic for sounds like [ǂ] and [ǂq]. That is, the pulmonic burst [ǂq] is phonetically predictable from the [suction] contour, which is not necessarily true: nothing is precluding the pulmonic burst from being realised at the anterior closure, given that this is the phonologically active Place of Articulation. An analysis using one Place of Articulation also implies that the differences between the anterior closure of the labial, alveolar, and lateral clicks are phonetically predictable, which is false.

Also accomplished by this model is a more extensive representation of vowel phonation types and articulations produced in the LVT for Kx’a and Tuu languages.

7 Conclusion

Throughout this thesis, various aspects of the phonology of complex root-initial onsets in KBA languages have been assessed. The languages investigated in this thesis were the Khoe-Kwadi languages Khoekhoegowab and Khwe, the Tuu languages !Xóõ and N|uu, and the Kx'a languages Ju|'hoan and Ekoka !Xun. In the introduction, three research questions were posed. Two questions concerned a unit versus cluster analysis of the onsets: the first being whether these onsets are more accurately represented as clusters or units, and the second being what theoretical repercussions arise when either analysis is proposed. A third research question was posed, this time regarding the broader phonology of onsets in KBA languages as illuminated by phonological patterns and behaviours of the onsets.

Ultimately, this thesis proves that Ladefoged (1968) was mistaken when he stated that the classification of sounds as units or clusters is mostly arbitrary. Through the systematic evaluation of phonological patterns, O/E ratios, and onset and syllable typologies, onsets in the six KBA languages are interpreted here as complex unitary phonemes. The investigation of these onsets finds evidence for a cluster analysis to be lacking, thus answering the first research question.

The second research question was answered through the evaluation of cluster and unit analysis theories. A cluster analysis of KBA onsets has theoretical lacunae: these include the overprediction of segments, the need for arbitrary constraints on which segments may cluster so that inventory asymmetries may be accounted for, and the violation of typological norms regarding sonority and syllable onset structure. The featural account of KBA language onsets within the unit analysis also has theoretical complications, such as dubious phonological implications of airstream features.

The unit analysis implies that onsets in KBA languages have subsegmental features that may account for the inventory patterns observed in these languages. This notion was central to the proposed feature geometry. Although the airstream features from the original unit analysis were not used, my feature geometry structure was premised upon the idea that the same set of features could characterise clicks and non-clicks alike and capture the similarities between the dorsal releases of ingressive and egressive obstruents while still accounting for the differences in the click and non-click inventories.

The formulation of the suggested feature geometry required extensive investigation of the phonological patterns and behaviours of KBA language onsets. Features characterising the movement of the tongue root, body and dorsum were extrapolated from BVC patterns. Co-occurrence restrictions on laryngeal segments were integral to the representation of LVT features. This co-occurrence restriction – renamed in this thesis as the Single Laryngeal Constraint – as well as phonetic and phonological information about the 'pharyngeality' or 'epiglottalisation' of certain segments quickly demonstrated that the laryngeal tract had been neglected in previous analyses of KBA languages. Thus, the third research question has been answered and has led to a feature geometry representation of complex onsets in some KBA languages.

KBA languages continue to be underrepresented in phonological literature – not to mention in broader social, political, and policy discussions – so there are many avenues for future research within this field. This project was complicated considerably by the lack of standard representation of phonemes in KBA languages, so future research would benefit from the addition of more frequent and diverse phonological studies of said languages. Further research could also be undertaken regarding assimilation patterns caused by coronal segments. The BVC has occupied the attention of linguists since Traill stated it as a constraint in 1985, and I suspect that patterns of coronal assimilation are more complex than previously assumed. Coronal segments generally could be further explored. My proposed feature geometry did not necessarily account for the contrast in anterior click closures or egressive coronal obstruents in an efficient or particularly satisfying way, and future research could refine the feature representations of these sounds. Another group of sounds warranting further exploration are the nasal obstruents. Accounting for segments such as voiced and voiceless nasal clicks, clicks with nasal venting, and preglottalised nasal stops was beyond the scope of my investigation, but these sounds must be accounted for in a full formal analysis of KBA languages. The challenges that arise in attempting to phonologically represent the phenomenon of voiceless nasal venting alone are extensive, which indicates that this is a topic requiring further research. Finally, the Khoe-Kwadi languages were not accounted for in my feature geometry model, as Khoekhoegowab and Khwe did not show the same phonological patterning as the Tuu and Kx'a languages. Thus, future research could investigate the formal analysis and representation of Khoe-Kwadi languages.

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