The Vowel System of Moloko

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"Now to Him who is able to do
immeasurably more than all we ask or imagine,
according to His power that is at work within us,
to Him be glory in the church
and in Christ Jesus throughout all generations,
for ever and ever. Amen."
Ephesians 3:20-21 (NIV)

ABSTRACT

This thesis will explore the vowel system of Moloko, a central Chadic language spoken in the Far North province of Cameroon, Africa. An analysis of the literature on Chadic languages of the central (or Biu-Mandara) branch shows that the key issue at stake is the relationship between surface and underlying vowel inventories. These languages have a wide range of surface phonetic forms which can be reduced to a smaller number of underlying phonemic vowels. This can be explained by an analysis of two key factors. Firstly the prosodies (in the Firthian sense of non-segmental features extending over a series of segments) of palatalisation and labialisation, which affect all vowels and some consonants in words bearing one of these prosodies at the level of the morpheme. Secondly vowel patterns, involving the presence or absence of a vowel at a particular level, whether phonetically or morphologically motivated. The analysis of Moloko in Bow (1997b and 1997c) indicated that at a certain level of abstraction, only one underlying vowel was needed in this language. The structure of the language was marked by the presence or absence of this vowel /a/, its absence being marked by the insertion of an epenthetic vowel to conform to the syllable structure of the language. An alternative analysis gives this epenthetic vowel the status of a phoneme, thus positing two phonemes in the underlying vowel inventory of the language. While both analyses succeed in accounting for the surface forms generated, the goal of the present work is to determine which analysis is preferable. The theoretical framework selected is Optimality Theory, where the ranking of universal, violable constraints gives an account of generated output forms from a given input. In this case however, rather than seeking the optimal output form for a given input, there is a choice between two input forms which give the same output, requiring the strategy of lexicon optimisation. An optimality-theoretic account of the application of prosodies is also required, before any decision can be reached on the optimal vowel inventory of the language.

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1. INTRODUCTION

1.1 Introduction

One of the goals of linguistic analysis has been to understand and characterise the relationship between underlying and surface forms in language. The tradition of generative phonology provided certain assumptions about this relationship, such as the requirement that underlying representations reduce to some minimum the phonological information used to distinguish lexical items (Lexical Minimality). This necessitates a range of phonological processes to supply the non-distinctive information missing from these forms, in order to arrive at Full Specification, requiring that the output of the phonological component must contain maximally specified feature matrices (Chomsky & Halle 1968). Some of these phonological processes are identical across all languages (thus linked to Universal Grammar), others are language specific or typologically characteristic. Some are crucially ordered, some are context-free rules of redundancy, and there are a number of different mechanisms available to explore these phenomena. In some cases the nature of the analysis selected may influence the results found, in others the level of abstraction chosen will determine certain features of the outcome.

In the current theoretical environment, while the procedures and formalisms may have changed, the concept of Lexical Economy has been maintained. The dominant phonological theory of the 1990s, Optimality Theory, exploits the antagonism between two competing principles, one requiring representations to be richly specified for phonetic qualities, and the other demanding feature minimisation and distinctiveness. Crucially ordered language-specific rules are replaced with ranked universal, violable constraints, and processes are viewed in parallel rather than serially.

The area of Chadic languages offers a rich source of information for this field of enquiry. The vowel systems of central Chadic languages have been analysed as having a large number of phonetically distinct vowels at the surface level which can be reduced to a much smaller number of phonemic vowels at a deeper level. The processes of palatalisation and labialisation, and specific vowel patternings are called on to account for this phenomenon.

The present research will focus on the central Chadic language Moloko, in an attempt to determine the optimal number of vowels required in its underlying vowel inventory. This particular language has received little attention in the literature, therefore any descriptive work on this relatively unknown language will be a worthwhile addition to the existing research on Chadic languages. To the author's knowledge, an analysis of Chadic phonology within the framework of Optimality Theory has not been previously attempted,[1] therefore detailed background on both areas is included here. It is hoped that the present work may offer insights into a larger field of enquiry within both Chadic and Optimality Theory.

1.2 Outline

The remainder of this introductory section will give a significant background to the language and its speakers, since very little information is available elsewhere. Section 2 considers the relevant background literature on vowel systems in Chadic

[1] See Samek-Lodivici (1998) for an OT analysis of the syntax of one Chadic language.

languages, particularly of the Central (a.k.a. Biu-Mandara) branch, focusing on the areas of prosodic features and vowel patterns. Section 3 looks these areas in the Moloko language, based on the analysis reported in Bow (1997b and 1997c). Section 4 lays out the basic principles and formalisms of Optimality Theory, before analysing the data through that theoretical framework. Section 5 summarises the results, drawing a conclusion about how many vowels should be posited in the underlying inventory of Moloko.

1.3 Moloko Language and People

Moloko is a Chadic language spoken in the canton of Makalingay, sub-division of Tokombéré, division of Mayo-Sava, in the Far North Province of the Republic of Cameroon. According to Barreteau & Newman (1978:303) the language is classified as follows:[2]

1)	family	Chadic
	branch	Biu-Mandara (Central)
	sub-branch	Biu-Mandara A
	group	Wandala/Mafa/Sukur
	sub-group	Mafa
	language	Moloko (82)[3]

In the literature, the language is sometimes referred to as Melokwo, Molokwo, Məlokwo, Molko, Molkwo, Molkoa, and Mokio (Grimes 1996).

There are approximately ten thousand speakers of this language (Starr 1997), mostly in the area surrounding Moloko Mountain, 30km north of Maroua, the capital of the Far North province. Small communities of speakers of the language are also found in and around the city of Maroua and other major towns in the north, as well as the national capital Yaoundé in the Centre-South province.

Like many of the mountain peoples of northern Cameroon, the Moloko are included in the term 'Kirdi', an Arab Choa word meaning 'infidel' or 'pagan,'[4] to distinguish them from the islamised Fulani. Traditionally, the Moloko are believed to have sought refuge on Moloko Mountain during the Fulani invasions of the 19th century. Today few people still live on the mountain itself, the majority having descended to the surrounding plains in search of water and better farming land. Many have converted to Christianity, with the Seventh Day Adventist Church being the largest in the area. The agricultural community is mostly made up of subsistence farmers, with the main crops being millet, peanuts and cotton. There are some merchants and public servants, however those with paid employment mostly live in urban centres outside the language area.

Moloko is surrounded by five different languages (counter-clockwise from the north): Muyang, Mbuko, Mikiri, Giziga and Fulfuldé (Fulani)[5] (Bradley 1992). All but Fulfuldé belong to the same sub-group of the central branch of the Chadic

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[2] See Bow (1997a) for a more detailed analysis of the classification of this language.

[3] The Atlas linguistique du Cameroun (Dieu & Renaud 1983:357) affirms this classification, but changes the name of the sub-branch from 'Biu-Mandara A' to 'Central West.' Throughout this paper, the term 'Central' will be used to refer to the particular branch of Chadic under consideration.

[4] This term can have a somewhat pejorative connotation (Pontié 1984:203). For a detailed account of the history of the 'montagnards' of North Cameroon, see Vincent (1981).

[5] 'Fulani' is the English name for both the people group and the language, corresponding to the French word 'peul'. Speakers of the language itself use the term 'fulfuldé' for the language and 'fulbé' for the ethnic group (Barreteau, Breton, Dieu 1984:172).

language family. Many people have some understanding and competence in one or more of these languages depending on the level of contact, and there is quite a high proportion of lexical similarity between closely-related languages (Barreteau & Sadembouo 1981). Moloko people often marry outside their language group, though only the husband's language is spoken in the home. Fulfuldé (a Niger-Congo language unrelated to Chadic) is the major trade language of the region, and is also often used in the church, though very few women speak or understand the language. Knowledge of the national language French is restricted to those few with some education. The low number of primary schools and complete lack of secondary schools in the Moloko area account for the low level of education.[6]

Until 1996 there was very little linguistic information available on this language, though certain researchers made references to it in studies of related languages (e.g. Rossing 1978, Blama 1980 and de Colombel 1982). The only monograph of Moloko was taken from a sociolinguistic survey led in 1992 by the Survey Department of SIL (Société Internationale de Linguistique, a.k.a. Summer Institute of Linguistics). This survey confirmed that Moloko is "a homogeneous, distinct speech form" which "appears to be a vital language and in no danger of being replaced in the near future" (Bradley 1992:4-5). A more in-depth sociolinguistic survey carried out in 1996 (reported in Starr 1997) showed that there are no distinctive dialects of Moloko, although accent differences can serve to indicate a speaker's village or area of origin. This survey also reported full intercomprehension between all speakers.

In 1996, at the request of the Moloko community, an SIL team was assigned to the area to work on linguistic analysis and establish a written form of the language, with a view to producing and translating vernacular literature. The data used in the present work was collected by the author as part of the SIL team, with the assistance of two native speakers of Moloko in Maroua and Yaoundé. Around 1500 lexemes were collected and transcribed by the author as field notes, and a few short texts in the form of folk tales were elicited and recorded on audio cassette. The quality of this cassette made instrumental analysis difficult, therefore the quality of the data depends on the accuracy of the researcher's impressionistic auditory phonetic transcription. The collected data was collated using software specifically designed for the management of linguistic data (Shoebox and FindPhone). Research was carried out under the auspices of the Ministry of Scientific and Technical Research of Cameroon between May 1996 and September 1997. The informed consent of the two Moloko language consultants was obtained, as well as permission from SIL for the researcher to use the data collected under their auspices.[7] The present work draws significantly on reports compiled by Bow (1997b and 1997c).

[6] See Starr (1997) for details about multilingualism, language use and language contact among the Moloko.

[7] Cameroon government research permit Nos. 080/MINREST/DOO/D20 (May 96 - May 97) and 076/MINREST/ BOO/DOO/D20/D21 (June - October 97). Ethical approval from the University of Melbourne Arts and Education Human Ethics Subcommittee received under HREC No. 990168.

2. CHADIC VOWEL SYSTEMS

2.1 Chadic languages

The Chadic language family[8] is a branch of the Afroasiatic phylum (Newman 1980) along with Semitic, Egyptian, Berber, Cushitic and Omotic. Chadic languages are spoken in the area around Lake Chad, mostly northern Nigeria, northern Cameroon and parts of Chad. The most widely spoken of the Chadic languages is Hausa, which has 25 million mother tongue speakers and is used by several million more as an important West African trade language. There are around 186 Chadic languages (Grimes 1996), divided into four branches: West (including Hausa), Central (or Biu-Mandara), East and Masa (Newman 1977).

2.2 Proto-Chadic vowels

The reconstruction of a Proto-Chadic language (PC) has been a goal of Chadicists for some time, with landmark works by Newman & Ma (1966) and Newman (1977). In the earlier paper, 145 words were reconstructed with consonants only, while hyphens were used to mark the position of vowels. This reflects the relative stability of consonants across Chadic languages, and the elusiveness of the vowels. Present-day Chadic languages have been analysed as having from one to twelve vowels, however no clear sound laws have been determined which can relate the systems across different languages.

According to Newman (1977), the characteristic Chadic pattern is six vowels: *a, ə, i, u, e, o.* Of these six, *e* and *o* often have secondary status, coming from one of three possible sources: a) loanwords, b) derivations from diphthongs (sequences of *a+y or *a+w), or c) conditioned variants of other vowels. In many languages, even the four remaining vowels are not fully contrastive, with the distinction between *i* and *u*, *ə* and *i*, and/or *ə* and *u* being neutralised in specific phonological environments. Most analyses acknowledge the importance of position within the word for identifying vowel contrasts, with different vowels contrasting in initial, medial or final position within the word. Newman suggests that "PC was characterised by the same type of distributional restrictions that one finds in present-day Chadic languages. Thus no blanket statement that PC had this or that number of vowels would be correct as such. Rather, one would have to specify how many vowels and which vowels did PC have in initial position, how many and which vowels in medial position in open syllables, etc." (Newman 1977:12).

At the time of Newman's seminal paper, there were some studies which illustrated various languages in which a wide range of phonetic vowels could be reduced to two or three phonemic vowels contrasting only in vowel height (e.g. Mirt 1969, Mohrlang 1971). Yet Newman was reluctant to commit to the claim that PC had only *ə and *a and that *i and *u were merely non-contrastive phonetic variants, though admitting that "the comparative evidence points in the same direction for PC" (1977:12). He considered that a choice lay between a two-vowel system /*ə, *a/ and a four-vowel system /*i, *ə, *a, *u/, with a balanced /*i, *a, *u/ system representing a remote possibility. Since then, especially with the significant

[8] A clear terminological distinction must be made between Chadic languages and Chadian languages, the latter of which refers to all languages spoken in the Republic of Chad.

work done on languages of the central branch of Chadic, the two-vowel system has become more and more accepted, to the point where a noted Chadicist could say in 1987 that "the fundamental opposition in Chadic languages between ə and a, or more exactly between tense and lax vowels (whatever their quality) is considered pertinent and admitted by the majority of Chadic researchers" (Barreteau 1987:180, my translation).

2.3 Prosodies

Lexemes in central Chadic languages show clear groupings of vowel patterns, as in the following examples of two and three syllable mono-morphemic words from Moloko.

2)

	meher	'forehead'	harats	'scorpion'	boɮom	'cheek'
	ɮige	'sow'	dəray	'head'	suk^{w}om	'buy'
	mebebek	'bat'	matabaɬ	'cloud'	mozoŋg^{w}o	'chameleon'
	tʃikele	'price'	gəgəmay	'cotton'	g^{w}ug^{w}oro	'ram'

Within a single morpheme, the vowels pattern together as either front, central or back vowels. At first glance, these patterns may appear to indicate a system of vowel harmony. However, the effects are not restricted purely to the vowels, but also apply to certain consonants. Instead of considering this as a process of assimilation, the evidence points to a pattern of prosodies as lexical components of the word as a whole, not just applying to particular segments. Unlike many vowel harmony systems, there does not appear to be a 'trigger' in Chadic languages (such as a process of affixation) which causes other segments to align with a certain feature or set of features.

Unlike the more familiar use of the term prosody in relation to a prosodic hierarchy (i.e. mora, syllable, foot, word), the term prosody is used here in the Firthian sense, referring to linguistic features beyond the level of the segment, such as variation in pitch, loudness, tempo and rhythm, which apply at the level of the syllable, morpheme, word, phrase or sentence. Features such as secondary articulation can also be included under this definition. In the Chadic case, two prosodies involving secondary articulations[9] – labialisation and palatalisation – are assumed to apply optionally at the level of the morpheme. It appears to be easier to speak of changes of prosodies rather than looking successively at vowel and consonant changes. Morpho-phonological alternations in the verb, noun and adjective show that prosodic changes are very productive in many Chadic languages (Barreteau 1987).

Labialisation is characterised phonetically by lip-rounding and raising the back of the tongue towards the velum (i.e. labiovelarisation). Its affect on Chadic consonants is usually to create the secondary articulation of lip-rounding, e.g. /k/ -> [k^{w}]. Its affect on vowels is to cause central vowels [a] and [ə] to be realised as back rounded vowels [o] and [u]. Palatalisation involves the superimposition of a raising of the front of the tongue toward a position similar to that for *I* on a primary gesture (Ladefoged & Maddieson 1996). In Chadic languages, this causes central vowels to

[9] Features such as nasalisation, glottalisation and voicing do not appear to function as prosodies in Moloko, and therefore will not be considered in this paper. Barreteau (1983) considers some of these issues in other central Chadic languages.

be ‘fronted’, i.e. [a] and [ə] are realised as [ɐ] and [i]. Its affect on consonants may be to create a secondary articulation, e.g. /p/ -> [p^{y}],[10] and/or to cause alveolar sibilants to realise a post-alveolar place of articulation, e.g. /s/ -> [ʃ], /dz/ -> [dʒ]. Most central Chadic languages make use of these prosodic traits, though in any language they may have slightly different affects. Barreteau (1987:89) stresses the importance of considering the vowel and consonant systems as interdependent. Section 3.2 will examine in more detail how these prosodies function specifically in Moloko.

According to Wolff (1981), palatalisation (‘y-prosody’) is reconstructed as the influence of a lost palatal or palatalised segment as the ultimate source of assimilation, and labialisation (‘w-prosody’) is reconstructed where the rounding effect cannot be attributed to a (labio)-velar or bilabial consonant of the base itself. Throughout Chadic, especially the central branch, a number of unexplained velar, labial or labiovelar consonants are observed, and this prosody may reflect the former presence of such elements in a given lexical item (in some cases still segments).

Other names given to these phenomena in the Chadic literature include “vowel harmonising” (Wolff et al 1981) within the mono-morphemic lexical base (as distinct from ‘vowel harmony’ which operates across morpheme boundaries), referring to the extensive assimilations of vowels by other vowels. In their analysis of eight central Chadic languages, Wolff et al (1981) noted that this process affected tongue height and worked from right to left, and was particularly noted in final and pre-final syllables. One important feature of ‘vowel harmonising’ systems according to their analysis was mutuality of assimilation, in that when vowels assimilate to each other, none of the affected vowels retains its original phonetic value, as in the following examples from Lamang.

3)	/awi/	[ewe]	‘mouth’
	/agu/	[ogo]	‘goat’

Hoskison (1983:15) uses the term ‘vowel colouring’ in his analysis of Gude, concluding that “vowels are basically colourless but assimilate the colouring of contiguous consonants.”

2.4 Vowel patterns

Various vowel patterns have been identified in Chadic languages, having either a phonological or morphological significance. In a consideration of the problem of vowel reconstruction in Chadic based on the Wandala-Lamang (WL) sub-group of the central branch, Wolff (1981) identifies two distinct ‘vocalisation patterns,’ based on the presence or absence of the vowel /a/ in word-internal positions. The prosodies of labialisation and palatalisation are assumed to account for vocalic surface realisations other than [ə] and [a], with those phonetic vowels viewed as neutral representations in lexical bases which reflect the two distinct vowel patterns. Firstly, zero-vocalisation means that the crucial position between the final and pre-final consonants of the base is not filled by the vowel phoneme /a/, therefore any vocalic element occurring in phonetic realisations of zero-vocalised bases in that position must be considered epenthetic. Secondly, a-vocalisation means that the position between the final and pre-final consonants is filled by /a/. The origins of this

[10] IPA conventions are followed throughout this paper, with the exception of the use of the symbol [y] to represent the palatal semi-vowel (IPA [j]), conforming with the conventions of Chadic research.

distinction are probably morphological for certain lexical items, such as separating marked and unmarked grammatical categories in dichotomous sub-systems. Newman (1990) identifies these patterns as commonly marking plurality among nouns and verbs, as seen in the following examples from Wandala-Lamang languages (from Wolff 1981:218):

4)	[-pl]	[+pl]	
Kdupe	zəre	zaara	'child/son'
Dghwede	dughwe	dghawa	'girl/daughter'
Lamang	kəla	kala	'take'

Morphophonological functions of vowel patterns are reported in a number of Chadic languages. R. M. Newman (1977) describes morpho-phonemic alternations in Ga'anda (a central Chadic language) caused by palatalisation affecting certain noun and verb stems. She points out that "although the various components of this prosody are phonologically interrelated, its application is ultimately determined by morphological factors" (1977:130). Frajzyngier (1981 and 1986) reports that all branches of the Chadic family have rules which raise or lower the vowels of a stem through suffixation, thus suggesting that such rules must have been present in Proto-Chadic.

A number of languages of the central branch present different vocalic realisations in final position depending on whether the word is cited before a pause or in context. Typically, before a pause a word may have a low vowel, which is realised as non-low in other environments. This means that the underlying form of final vowels can be very difficult to discern. In particular, there may be extremely varied realisations of schwa in this position. Barreteau (1983) suggests that the pausal form may not be the most significant in determining the nature of the final vowel. Sections 3.4 and 4.4 of the present work will consider this phenomenon in Moloko.

2.5 One or two vowels

One of the first analyses of a Chadic language to suggest that the underlying system could be reduced to just two vowel phonemes /ə, a/ is the paper on Wandala (also known as Mandara) by Mirt (1969). Other vowels were explained as allophonic variants resulting from assimilatory processes or positional influences. Wolff et al (1981) extended this analysis to an even more abstract level, suggesting that a non-segmental phoneme (which they symbolise as */**.**/) would account for occurrences of schwa and the high vowels [i] and [u], thus leaving Wandala without any true vowel contrasts. "It remains to be seen whether this constitutes an idiosyncratic development in this language or rather reflects the true nature of a proto-language" (Wolff et al 1981:272). While detailed discussion of the nature of proto-Chadic is strictly beyond the bounds of the present work, my data would support the suggestion that Wandala is not idiosyncratic in its vowel system, but similar claims could be (and have been) made for Moloko and other central Chadic languages.

Based on a phonological interpretation of the Higi language, Barreteau (1983) formulates some general hypotheses about prosodies in the ensemble of Chadic languages, or at least those of the central branch. In these languages he observes a common basic system with the same ensemble of prosodic features applying differently according to the language. Regarding the segmental system, there are two syllable types (CV and CVC), a minimum of two tones (certain languages have mid

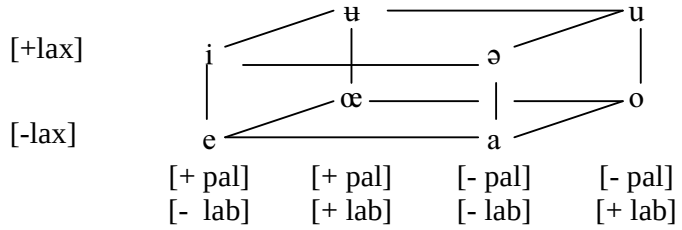
tones and some allow contours), 23 consonant phonemes (excluding prenasalised, palatalised or labialised segments), and a vowel system founded on two basic vowels: ə, a (distinguished by the feature +/- tense). The structural analysis advocated by Barreteau, in bringing out the prosodic and phonemic features, allows for highly divergent phonological systems to be brought together, while maintaining that the application of the prosodic features essentially differentiates these languages.

Following on from this generalisation, in a 1987 paper on Chadic vowel systems, Barreteau comments on "the extreme richness of phonetic realisations at the same time as the disparity between the systems. In the analysis of particular languages, it is not unusual to find numerous variants, free variation, contextual variation according to the position of the vowel within the syllable, within the word, within the phrase, or variation conditioned by the consonantal environment" (Barreteau 1987:161). He considers that three features suffice to account for the structure of all systems observed: a segmental trait of 'relâchement' ('laxness'), and two prosodic traits: palatalisation and labialisation. Laxness characterises the opposition between tense and lax vowels: lax vowels are short, evanescent, sometimes interpreted as epenthetic or zero vowels, while tense vowels are longer, open, have more stable timbres. The distinction between tense and lax corresponds to the opposition between two degrees of openness, sufficient to characterise the systems under consideration. A combination of prosodic traits gives four vowel qualities:

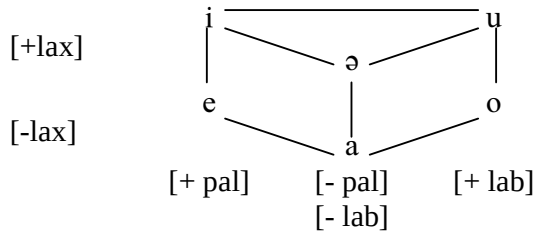
5)	+pal,	-lab	(front, unrounded)
	+pal,	+lab	(front, rounded)
	-pal,	-lab	(non-front, unrounded)
	-pal,	+lab	(non-front, rounded)

Barreteau goes on to identify seven types of vowel system in 16 central Chadic languages analysable in terms of these three traits, as shown in the following tables (from Barreteau 1987:163-164):

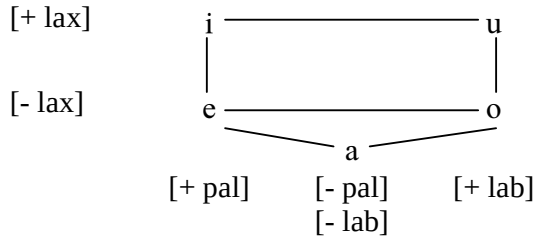
6) Mafa, Zulgo, Daba, Kaɗa



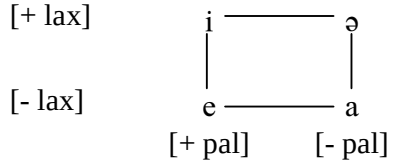
b) Giziga-North, Mofu-North, Lame



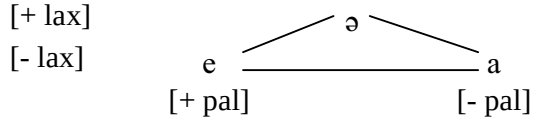
c) Munjuk, Masa



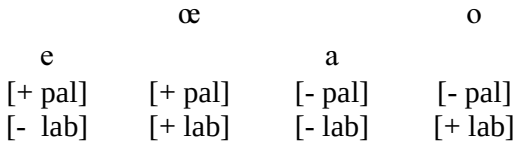
d) Higi, Podoko



e) Mofu-Gudur



f) Maɗa



g) Wandala, Pələsla, Wuzlam (Ouldémé), Guɗe

The simplest systems are those where the analyses are the most abstract (two vowels), relying just on the opposition of laxness. Barreteau points out however that fine phonetic transcriptions could reveal the full eight vowel system possibly in all these languages. The surface realisations indicate that the traits of palatalisation and labialisation hold principally on the consonants and secondarily on the vowels.

Typologically, the prosodic analysis proposed by Barreteau allows comparison with apparently very different systems, going from 8 vowels to 2, and from 119 consonants to 26.[11] Eight vowels in Mafa rest on simple opposition between tense and lax, and in all systems, palatalisation and labialisation are suprasegmental prosodic traits. The abstraction of these prosodic traits can bring out the common elements between languages. Inversely, the application of these prosodic traits of palatalisation and labialisation varies enormously from one language to another.

[11] For example [mp, p^w, p^y, p] all reduce to a single phoneme /p/.

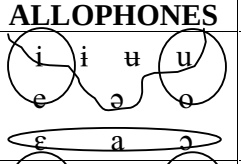
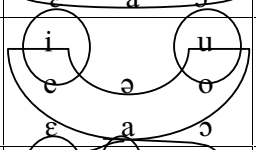
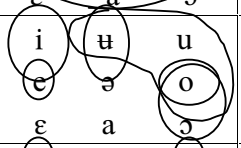
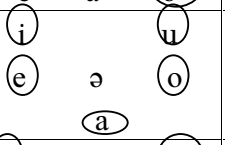
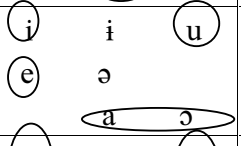
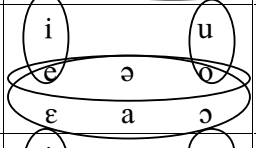
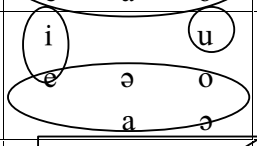
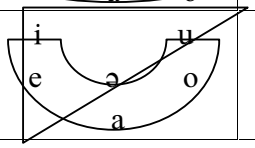
In a further analysis of Mofu-Gudur in the same paper, Barreteau examines two hypotheses, differing in the phonemic status of schwa. If /ə/ is a phoneme, then the contrast with /a/ is neutralised in certain contexts. Alternatively, a system with only one underlying vowel gives /ə/ the non-phonemic status of an epenthetic vowel. Observations of convergence between languages of the Mafa and Lamang groups allow Barreteau

> "to confirm the hypothesis in Chadic languages with one sole vowel (or without vowels, i.e. without segmental vowel oppositions). (…) In conclusion, we observe that the foundation of our hypotheses is assured by the vivacity of facts observed in Chadic languages of the central branch: the prosodic alternations and the phenomena of vocalisation (syncope/ epenthesis) have quite operative grammatical functions of which the speakers are clearly aware" (1987:189-190).

Along the same lines as Barreteau's analysis, Wolff states that "*on the chosen level of abstraction*, only one phonemic vowel is needed" for Wandala-Lamang (WL) languages (1981:148, emphasis mine). All phonetic vowels in modern WL can be derived from /a/ or syllabic manifestations of /y/ or /w/, or are epenthetic.

The significance of position within the word in determining vowel contrasts is examined by Wolff et al (1981). This examination of the vowel systems of eight central Chadic languages led to the conclusion that each language probably has three vowel phonemes and one diphthong, as indicated in the following table:

7)

LANGUAGE	OVERLAP OF ALLOPHONES	INITIAL	MEDIAL	FINAL
Dghwede			i u a	i -> [i] -> [e, ø] a
Glavda		i u a	i u a	i a͡i a͡u a
Gvoko		i u a	i u a͡i a͡u a	i u ai a͡u a
Gwara		i u a	i u a	i u a͡i a͡u a
Kdupe		i u a	i u a͡i a	i a͡i a
Lamang		i u a	i u (ə) a	i u (ə) a
Podoko (simplified)		i u a	i u a	i u a͡i a
Wandala		ə a	ə a	ə a

According to their analysis, schwa is not required as a phoneme in diachronic perspective, but rather served as a pro- and/or epenthetic vowel which is conditioned by syllable structure (governed by the rules of syllable peak assignment), with its phonetic shape dependent on features of adjacent segments. They propose that maximally three segmental monophthongs (*i, *a, *u) are sufficient for a common proto-language for central Chadic, however they leave open the possibility that *i and *u could be simply syllabic manifestations of *y and *w rather than separate phonemes. This drastically reduces the vowel inventory required for these languages. Continuing this theme in the analysis of Proto-Wandala-Lamang (PWL) in Wolff (1981), schwa is denied the status of a vowel phoneme, since its occurrence, plus that of other extra short phonetic vowels such as [ɪ] and [ʊ], are viewed as pro- and/or epenthetic, their actual colouring being predictable from the surrounding consonants. [i] and [u] are not separate phonemes beside /y/ and /w/ in the proto-language, since they occur as either syllabic or non-syllabic, and where [i] and [u] are not syllabic realisations of /y/ and /w/, they are segmentalised manifestations of

the palatalisation and labiovelarisation prosodies in positions of epenthetic vowels. Wolff concludes that PWL lexical items can be reconstructed with just one phonemic vowel /a/, which is either part of the lexical base, or (in medial positions) is a morphological extension of the base through a-vocalisation.

Like Barreteau, Wolff's analysis uses the prosodic and vocalisation pattern approach to remove the problem of lack of vowel correspondences in these languages, leaving behind straightforward a:a and a:∅ cases as well as regular correspondences between consonants. At this highly abstract level of phonological analysis, only one phonemic vowel is needed: /a/ which contrasts with its absence. At least six vowels result from the presence or absence of two prosodies: the phonetic vowels [a, e, o] are allophones of /a/, while the phonetic vowels [ə, i, u] are basically epenthetic in nature. The presence or absence of /a/ in medial position/s distinguishes two vocalisation patterns with morphological correlates. Commenting on the possibility of postulating two phonemic vowels /a/ and /ə/, Wolff says:

> "at present I am convinced that, taking all evidence together, two-vowel systems in Central Chadic, whether contrasting in height or frontness, allow further analysis and can be reduced to a system in which only one 'vowel' contrasts with its absence, i.e. a system without true vowel contrasts! … It appears feasible that such a system contains the answers to the questions of how and why present-day Chadic languages have the kinds of vowel systems they have. The development of true vowel systems with between two and six, nine or even more vowels, according to this theory, can be attributed to phonemicisation of allophones of certain sonorant consonants and epenthetic vowels, with the prosodies of palatalisation and labiovelarisation playing an important role in creating an even wider range of variation." (Wolff 1983:226).

He goes on to comment that the Wandala-Lamang group and other groups of languages within Central Chadic may reflect the whole Chadic vowel history, with synchronic six-vowel systems based on analysis at a shallow level of phonological abstraction, originating from a diachronic no-vowel system analysed at a very high level of phonological abstraction.

2.6 Other branches of Chadic

The fluidity of vowel systems is only seen in languages of the central branch of the Chadic language family. Jungraithmayr (1992) differentiates between vowel patterns in the central languages and those of the western and eastern periphery of Chadic. Unlike languages of the 'central nucleus', i.e. the Lamang, Mandara and Mafa-Mofu groups (including Moloko), "in non-central-nucleus languages an *a* is and remains an *a*, with its immutable qualities and semantic properties, irregardless (*sic*) of its consonantal and/or morpho-syntactic environment" (1992:119). In 'peripheral' Chadic languages of the western and eastern branches, vowel quality is always functional. These languages characteristically display the 'classical' five vowel qualities, *a, e, i, o, u,* with no phonetic variability, while variation is an active part of morphological processes which contribute essentially to the make-up of a grammatical system, as in the following examples from languages of the eastern branch:

7)	*Language*	*gloss*		*Infinitive*	*Perfective*	*Imperfective*
	Mubi	'to burn'	sg	fogony	fuguny	fugoony
			pl	fakkany	fekkiny	fikkaany
	Migama	'to fall'	sg	suubo	suube	sobaa
			pl	subbo	subbe	sobokka
	Mokilko	'to divide'			ɗiikiɗa	ɗokkiɗe

Jungraithmayr concludes that in general, vowels in the west and the east are immutable qualities unaffected by environmental influences, which play an important role in morphology, defining grammatical functions such as nominal and verbal plurality, verbal aspect stems, etc. Comparing this to the more vague and 'floating' nature of vowel qualities of the central nucleus languages, he formulates the following general linguistic evaluation of the opposing vowel system types in Chadic:

> "The more functional load and morphological weight vowels have to carry –as it is the case in West-East peripheral Chadic – the less flexible they can afford to be in phonological/phonetic respect. On the other hand, the less morphological weight they are charged with – as in the Central nucleus languages – the greater their phonetic/phonological and phonosyntactic variability may be" (Jungraithmayr 1992:127).

2.7 Summary

This overview of the relevant background literature on vowel systems in Chadic has indicated the possibility of reducing the surface phonetic vowel inventory of central Chadic languages to a much smaller number of underlying phonemic vowels. Considering the processes of palatalisation and labialisation as morpheme-level prosodies means that front and back vowels can be considered prosodically-motivated allophones of central vowels. The height distinction between /ə/ and /a/ can further be reduced at a more abstract theoretical level to a distinction between the presence or absence of a vowel in certain positions within the word. In the following section, this type of analysis will be applied to data from the Moloko language.

3. MOLOKO PHONOLOGY

In this section, an overview of Moloko phonology will be given according to a traditional generative analysis, based on Bow (1997b and 1997c). There are three important points to consider about the Moloko language in this section: the syllable structure, the prosodies, and the vowel inventory.

3.1 Syllable structure

The syllable in Moloko is made up of the following components: consonant, vowel, tone, and (optionally) prosody. The most basic syllable type in Moloko is CV. It may be reasonable to suppose that all words are made up of CV syllables, since the exceptions to this rule are regular and easily explainable. Closed syllables only occur word-finally, and syllables without onsets are restricted to the vowel [a] word-initially. Some resyllabification occurs in fast speech, and liquids can also create exceptions to the standard rule. There are no segmental restrictions on onsets, and minimal restrictions on coda consonants. The consonant inventory of Moloko contains the following units: /p, b, m, mb, ɓ, f, v, t, d, n, nd, ɗ, ts, dz, s, z, nz, ɬ, ɮ, l, r, y, w, k, g, ŋg, h, k^w, g^w, $ŋg^w$, h^w/. Certain consonantal sequences are treated as single units, as they cannot be separated by a vowel in careful speech. These include prenasalised consonants [mb, nd, nz, ŋg], affricates [ts, dz, tʃ, dʒ] and labialised consonants [k^w, g^w, $ŋg^w$, h^w]. Moloko has three register tones: high, mid and low, and a series of tone melodies on lexical items.[12] Length is not phonemic for either vowels or consonants in Moloko.

One significant area in which the canonical syllable structure is violated is linked to the presence of liquids /r/ and /l/. Liquids in Moloko function differently from other consonants with respect to syllabification, in that they can function as:

(a) the nucleus of a syllable

(b) the coda of a non-word-final closed syllable, or

(c) the second component of a complex onset.

In each of these cases, the canonical structure can be reconstructed in careful speech with a vowel (schwa or one of its allophones), thus resulting in free variation, as seen in the following examples.

8)	a) nucleus	[l.vaŋ]	~	[lə.vaŋ]	'night'
	b) coda	[kər.pa.ɬa]	~	[kə.rə.pa.ɬa]	'wings'
	c) complex onset	[ma.dras]	~	[ma.də.ras]	'pig'

It should be noted that this same variation is not apparent when liquids are adjacent to low vowels (/a/ or its allophones).

9)	[harats]	'scorpion'	*[hrats], *[harts]
	[lehe]	'bush'	*[lhe]

The significance of this issue will be considered in section 4.3.

[12] Tone has both a lexical and grammatical function in Moloko. See Bow (1997c) for analysis of the tonal system, and see section 5.1 for a comment on the issue of tone on epenthetic vowels.

3.2 Prosodies

Moloko lexical items optionally carry a prosody of either palatalisation or labialisation at the level of the morpheme. Any prosody affecting the word will affect all vowels and certain consonants (refer examples in (2), section 2.3). As mentioned in section 2.3, within a single morpheme all vowels pattern together as either front (palatalised), central, or back (labialised). Moloko phonology prohibits the crossing of these boundaries, i.e. *CiCa, *CəCo, *CuCəCeC, etc., with certain systematic exceptions (see examples 16 and 17 following).

The prosodies have a lexical function, distinguishing between word meanings in a similar fashion to lexical tone. The following example shows words with the same consonantal and syllabic structure, differing only in the prosodies, which create the contrastive vowel realisations.

10)	No prosody:	[kəra]	'dog'
	Palatalisation:	[kire]	'stake/post'
	Labialisation :	[k^{w}uro]	'ten'

Among nouns, the prosodies carry no morphological information, as there is no apparent semantic relationship between the lexical items in example (10). In verbs however, the prosodies can bear some morphological significance, as shown in the following example (11) giving the paradigm for the verb 'to see'. In its citation form (second person singular imperative), it has no prosody. In the second person plural imperative form, it takes a suffix /-Vm/ and a labialisation prosody, while the infinitive form takes a prefix and a suffix and a palatalisation prosody.

11)	2sg imperative	[mənzar]	'(you sg) see!'
	2pl imperative	[munzor -om]	'(you pl) see!'
	Infinitive	[mi- minʒer -e]	'to see'

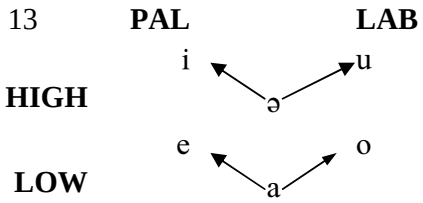
The analysis in Bow (1997b and 1997c) suggested the possibility that the prosodic features of the suffix 'spread' to the root, however there is insufficient evidence for a strict directional spread in the language, as other affixes affected by prosodies (such as certain possessive suffixes) do not spread in the same way.[13]

12)	[harats]	+ 2sg poss [-oŋg^{w}o]	[harəts-oŋg^{w}o]	'your scorpion'	*[horuts-oŋg^{w}o]
	[ɬala]	+ 1pl exc poss [-lime]	[ɬala-lime]	'our village'	*[ɬele-lime]

The example of [mənzar] 'see' given above (11) shows how the vowel /a/ is realised as [o] in labialised forms and [e] in palatalised forms, while schwa is realised as [u] in labialised forms and [i] in palatalised forms.

[13] Detailed discussion of the morphophonology of Moloko is beyond the scope of this study (refer Bow 1997c).

13



The effect of the prosodies is restricted to certain consonants in Moloko. Palatalisation is realised only on alveolar sibilants and affricates, while labialisation only is only realised on back consonants (velars and /h/).[14]

14)	/s/ →	[ʃ]	[mbasay]	'smile/laugh'	[mbeʃeŋ]	'breathe'
	/z/ →	[ʒ]	[zəŋzaŋ]	'mouse'	[ʒiŋʒeŋ]	'darkness'
	/ts/ →	[tʃ]	[mətsapar]	'multiple'	[mitʃepe]	'to drape'
	/dz/ →	[dʒ]	[dzaŋ]	'prick'	[dʒeŋ]	'chance'
	/nz/ →	[nʒ]	[nzavar]	'young man'	[nʒemer]	'artery'

15)	/k/ →	[k^w]	[sakay]	'sift'	[suk^woy]	'clan'
	/g/ →	[g^w]	[magats]	'claw'	[mog^wom]	'house'
	/ŋg/ →	[ŋg^w]	[maŋgaz]	'rust'	[moŋg^wom]	'horn'
	/h/ →	[h^w]	[haɗa]	'much'	[h^woɗo]	'wall'

Besides these realisations motivated by prosodies, Moloko also has a series of underlyingly labialised consonants: /k^w, g^w, ŋg^w, h^w/ (Bow 1997c:19-20). These account for other apparent contraventions of the rule of vowel patternings, as suggested by the following lexical items.

16)	[tuk^wurak]	'partridge'	/tək^wərak/	*[tuk^wurok^w]	
	[g^wula]	'son'	/g^wəla/	c.f. [g^wulo]	'left'
	[h^woɗa]	'dregs'	/h^waɗa/	c.f. [h^woɗo]	'wall'

Therefore the surface realisation of a labialised velar has two possible sources: it may be underlyingly labialised or affected by a morpheme-level labialisation prosody.

Other contraventions of the rules of vowel patterning[15] involve the assimilation of [ə] adjacent to semi-vowels.

17)	ə + y = i	[kiya]	'moon/month'
	ə + w = u	[ɗuwa]	'milk/breast'

[14] /h/ is selected as the phoneme here because of its wider distribution than the allophone [x] which is realised only in word-final position (Bow 1997c:30). Paul Newman (personal communication) points out that diachronically, it seems likely that /x/ is the phoneme). With the labialisation prosody, /h/ can realise four different allophones: [h, h^w, x, x^w].

[15] Words beginning with /a/ form another category of lexemes which do not conform to the vowel patterns of the language. See Bow (1997c) for discussion of the Moloko data, and Downing (1998) for a prosodic account of onsetless syllables.

The vowel /a/ is not affected by this rule, and the semi-vowels themselves do not trigger palatalisation or labialisation across the whole morpheme, as indicated by the following examples:

18)			
	[layaw]	'large squash'	not *[leyew], *[luyow]
	[yaɗay]	'tire'	not *[yeɗey]
	[gənaw]	'animal'	not *[gunow]

3.3 Phonetic vowel inventory

Three features are sufficient to distinguish the surface phonetic vowels of the language. as shown in the following table.

19)	**i**	**e**	**ø**	**ə**	**a**	**o**	**u**
LOW	-	+	+	-	+	+	-
FRONT	+	+	+	-	-	-	-
ROUND	-	-	+	-	-	+	+

The features [front] and [round] correspond to the prosodies of palatalisation and labialisation respectively. The choice of [low] as the third distinguishing feature is justified on phonological rather than phonetic grounds. Phonetically, the characterisation of [e] and [o] as [+Low] is problematic, however phonemically the quality of height appears to be more salient than a feature such as [+/- lax] (as proposed by Barreteau 1987). Since phonologically there is no contrast in Moloko between [e] and [o] and their slightly lower counterparts [ɛ] and [ɔ], the use of the symbols [e] and [o] should be seen as a convenient transcription to represent the phonetic forms [ɛ] and [ɔ], which would more accurately suit the characterisation [+Low]. The analysis in Bow (1997b and 1997c based on the author's field notes) listed the following surface phonetic vowels: [i, ɪ, ɛ, œ, ə, a, ɔ, ʊ, u].[16] A prior analysis of Moloko phonology (Rossing 1978) listed seven phonemic vowels differing slightly in the detail of height/laxness: /i, e, ø, ə, a, o, u/. The present study will maintain the use of the symbols used by Rossing, which is also consistent with the majority of the Chadic literature. Schwa functions as a [-Low] vowel, and may phonetically be realised slightly higher (i.e. [ɨ]). The present characterisation allows schwa to function as the unmarked vowel, which is important to the consideration of epenthesis in the language.

The low front rounded vowel [ø] has a special status in Moloko, being derived from the combination of an underlyingly labialised consonant and a palatalisation prosody, as indicated by the following minimal pairs.

20)			
	[ʃilek]	'jealousy'	(palatalisation prosody, non-labialised /k/)
	[ʃiløk^{w}]	'broom'	(palatalisation prosody, underlyingly labialised /k^{w}/)

[16] [i] and [u] were considered allophonic variants of [ɪ] and [ʊ] assimilating to semi-vowels [y, w] (Bow 1997c:11-12).

[dzug^{w}or]	‘stake’	(labialisation prosody, /ɡ/ affected by prosody)
[dʒøg^{w}er]	‘limp’	(palatalisation prosody, underlyingly labialised /g^{w}/)

While this rounded vowel is generated by the palatalisation prosody, it is distinct from the prosody of labialisation, relating only to the segmental effects of labial assimilation (as in example 16 above), as opposed to the morpheme-level effects of the labialisation prosody. The prosody of labialisation can be understood to include the features [+back] and [+round], without affecting the status of this vowel. The phonetic gap left by the absence of a non-low front rounded vowel [ü] (IPA [y]) is filled by the realisation of the non-low back rounded vowel [u], e.g. [mituweʒ] ‘sorrel fruit’.

The identification of front and rounded vowels as allophones of the central vowels means that the underlying vowel inventory is drastically reduced.

3.4 Vowel patterns

As in other central Chadic languages (refer section 2.4), Moloko realises different surface vowels in final position according to context. In citation form (i.e. before a pause), every Moloko word ending in a closed syllable has a [+Low] vowel in the final syllable. In context, when followed by another syllable (either a morpheme affix or a separate word in an utterance), the vowel in the final syllable is always [–Low] (refer section 2.4) .

21)	CITATION FORM:	[ɗaf]	‘food’	(isolation)
	CONTEXT FORM:	[ɗəf-ula]	‘my food’	(morpheme boundary)
	CONTEXT FORM:	[ɗəf atsar]	‘(the) food is good’	(word boundary)
	PRE-PAUSAL:	[na zum ɗaf]	‘I eat food’	(phrase final)

Moloko words ending in open syllables do not submit to the same processes as those ending in closed syllables. They retain the value for the feature [Low] of the underlying form, even across morpheme and word boundaries.

22)	CITATION FORM:	[ɬala]	‘village’	(isolation)
	CONTEXT FORM:	[ɬal-ula]	‘my village’	(morpheme bdry)
	CONTEXT FORM:	[ɬala nʒe]	‘(a) village is there’	(word bdry)
	PRE-PAUSAL:	[nə mənzar ɬala]	‘I see (a) village’	(phrase final)

Primary stress in Moloko always falls on the final syllable in a word, which may influence the quality of the final vowel. The addition of a suffix shifts the stress, and results in a change in the final vowel of the root.

23)	[haˈrats]	‘scorpion’	+ plural suffix [-ahay]	[harətsaˈhay]	‘scorpions’
	[tʃiˈdʒe]	‘illness’	+ adj marker [-ga]	[tʃidʒiˈga]	‘ill’
	[boˈɮom]	‘cheek’	+ 3pl poss [-atəta]	[boɮumatəˈta]	‘their cheek’

This suggests that any contrast between vowel height in this context is neutralised.[17]

In non-final position within the morpheme, it is not predictable whether a vowel slot will be +/-Low. The following minimal pairs give evidence for this:

24)	[bəlay]	'sea'	[balay]	'wash'
	[dəray]	'head'	[daray]	'plant'
	[mbəɗay]	'change'	[mbaɗay]	'swear'

In a few cases, morphological processes will give evidence for vowel height. The following examples of reduplication show contrast in vowel height of the root which is not transparent from the final vowel itself.

25)	No [+Low] vowel	[tʃimtʃem]	'(type of) tree'
	One [+Low] vowel	[tʃetʃe]	'louse'
	[+Low] vowel in first syllable only	[kekiɓkekeɓ]	'sharp' (ideophone)
	[+Low] vowel in second syllable only	[huvothuvot]	'softness' (ideophone)

There are also cases of morphological motivation for underlying /a/ vowels in words. Moloko verb roots can be characterised by the contrast in vowel height in the underlying form (such as the [mbəɗay / mbaɗay] contrast in (33) above). One result of this is the case of two words having the same surface representation yet differing in their underlying forms. The following example shows two verbs with identical surface forms in the second person singular imperative form, yet in the second person plural imperative (formed by the affixation of [-om] and a labialisation prosody), the differences are evident in the surface form:

26)		'climb'	'taste good'
	2sg	[tsar]	[tsar]
	2pl	[tsurom]	[tsorom]

In this case, the presence of /a/ in the underlying form is a morphologically/ grammatically motivated insertion, as opposed to the phonologically motivated epenthesis of schwa to break up consonant clusters. This is probably a reflex of some morphological contrast, along the lines suggested in Newman (1990) for pluractionality in verbs, though any semantic relationship in this case is completely obscured.

3.5 Two-vowel hypothesis

The reduction of the seven surface phonetic vowel qualities of Moloko to two underlying vowels is a simple process of signalling the prosodies of palatalisation and labialisation as applying to the whole morpheme. This process sees the non-central vowels as prosodically-motivated allophones of the two central vowels: [i] and [u] are allophones of the [-Low] vowel /ə/, while [e] and [o] are allophones

[17] See Steriade (1994) and Beckman (1996) for a consideration of positional neutralisation phenomena, including the preference of certain linguistic positions to license contrast, e.g. peripheral syllables, stressed syllables, etc.

of the [+Low] vowel /a/. These two vowels contrast only in vowel height, a contrast which is neutralised in the final syllable of a lexical item. While all non-final vowels must be specified as to the feature [Low] in the underlying representation of the word, in final position this feature is predictable by context. This neutralisation of contrast means that the quality of the vowel to be posited in that position in the underlying form is underspecified. The underlying forms according to this hypothesis would therefore make explicit all vowel slots, leaving the final slot unspecified for the feature [Low]. The [-Low] phonemes may be deleted in certain environments (e.g. in fast speech, or next to liquids), while [+Low] vowels cannot be deleted in these environments. The two-vowel hypothesis creates a transparent relationship between underlying and surface representations in the language.

3.6 One-vowel hypothesis

The reduction of the two-vowel hypothesis to one vowel is on some levels a simple question of the degree of abstraction chosen. Since the two vowels contrast only in the feature [Low], and this contrast is neutralised in final position, the contrast can be made explicit by the presence or absence of a vowel in any position. The syllabification rules of the language force the epenthesis of a vowel segment to break up consonant clusters. [+Low] vowel slots would be indicated in the underlying form, while no [-Low] slots would be required. Epenthesis is enforced in almost all cases, with the exception (as noted above) of cases of fast speech and proximity to liquids. This can be seen as a case of radical underspecification, the presence of a vowel in the final slot being redundant: its surface presence is forced by the syllabification rules, and its quality is determined by context. This hypothesis corresponds to both Barreteau and Wolff's conclusions given above (2.5), and signifies that the status of schwa is no longer phonemic, but rather is as an epenthetic vowel, phonetically motivated to break up consonant clusters.

3.7 Summary

From this it can be seen that the analysis of Moloko with either one or two underlying vowels can successfully account for the data, depending on the chosen level of abstraction. Both hypothesis are predicated on the principle of Lexical Minimality, where underlying representations reduce to some minimum the phonological information used to distinguish lexical items. Both front and rounded vowels are not required in the underlying form, since their surface form is achieved through the processes of palatalisation and labialisation affecting a smaller number of underlying vowels. Only central vowels are therefore required which will license the prosodic effects. The issue of vowel patterns is significant in considering the context in which the word is to be considered.

In the following section, the theoretical assumptions and formalisms of Optimality Theory will be examined, and the data analysed accordingly, in an attempt to determine if one system is to be preferred over the other.

4. OPTIMALITY THEORY

4.1 Theoretical background

Optimality Theory (henceforth OT) (Prince & Smolensky 1993) is a rapidly developing theory of constraint interaction in generative grammar. As noted in section 1, OT is predicated on the notion that language is a system of conflicting forces, which are embodied by constraints. Constraints have been considered alongside rules in phonology for many years, however the crucial distinguishing feature of OT is that it allows violations of these constraints. Constraints are considered to be universal, that is, all constraints are present in all languages. The differences in phonologies of various languages are due to the differences in rankings of these constraints, creating cross-linguistic variation and different language typologies. In contrast to traditional derivational analyses where rules are usually assumed to apply in a particular order ('serially'), and this order may be crucial, in OT potential surface forms are scanned for violations of constraints, and how well constraints are satisfied is evaluated simultaneously for all constraints ('in parallel'). What determines the outcome is not the serial ordering of rules, but the relative strengths, or rankings, of the constraints. The optimal form is that which incurs the least serious violations of a set of violable constraints, ranked in a language-specific hierarchy. OT appears to be particularly fit for modelling a theory which has to formally connect invariant and variable phenomena, synchrony and diachrony, variation and change, and even typological variation in adjacent dialects.

The parallelism of OT means that constraints will come into conflict, i.e. in order to satisfy one constraint, another constraint must be violated. OT proposes a mechanism for ranking the constraints of a specific language, where higher-ranked constraints take priority over lower-ranked ones. Two forces are fundamentally in competition in any language: *markedness*, the idea that certain types of structure are universally favoured over others, and by which languages tend toward unmarked types of structure; and *faithfulness*, those factors which preserve lexical contrasts, by requiring the output to be harmonious with the input. The ranking of constraints within these two areas is central to OT. The framework allows for parallel assessment of different output forms from the same input, and generates the optimal output according to the ranking of the specific constraints.

4.2 Architecture

The OT grammar is an input-output mechanism which pairs an output form to an input form. It consists of the following components (Kager 1999:19):

i) **LEXICON:** contains lexical representations (or underlying forms) of morphemes, which form the input to:

ii) **GENERATOR (GEN):** which generates a potentially infinite set of output candidates for some input, and submits these to:

iii) **EVALUATOR (EVAL):** the set of ranked constraints, which evaluates output candidates as to their harmonic values, and selects the optimal candidate. The actually occurring output form is that candidate which best satisfies the constraint system (i.e. passes the highest-ranked constraint).

One of the most important features of the Lexicon in OT is that no specific property can be stated at the level of the input form.

27) **Richness of the Base:** no constraints hold at the level of the underlying form.

This says that lexical representations in any language are free to contain any kind of phonological contrast. In the context of the present analysis, this allows us to explore the possibilities of either one or two (or even more) underlying vowels in the inventory of Moloko.

The theory is formalised through the use of tableaux, which demonstrate the interaction between applicable constraints in determining the most harmonic form from a subset of outputs.

28) Sample tableau

Input /x/	**CONSTRAINT 1**	**CONSTRAINT 2**	**CONSTRAINT 3**
Candidate [a]	*!		
Candidate [b]		*	*!
☛ Candidate [c]		*	

A number of possible outputs are listed in the leftmost column under the input. The constraints are ordered left to right across the top according to their ranking (i.e. CONSTRAINT 1 >> CONSTRAINT 2 >> CONSTRAINT 3). A solid line between two constraint columns signifies that one is ranked higher than the other; where the ordering is not crucial, the line is not solid. The optimal candidate is indicated by a pointing finger (☛). Empty cells indicate that a form conforms to a constraint, while violations of constraints are indicated by an asterisk (*). Fatal violations, which eliminate candidates from being considered optimal, are denoted by (!), and any following cells are shaded to signal their irrelevance.

4.3 Markedness vs faithfulness

The two key features of language exploited by OT are markedness and faithfulness. Markedness states that all types of linguistic structure have two values, one of which is marked, the other unmarked. The unmarked values are basic in all grammars, and are preferred across languages, while marked values are avoided across languages and are used only to create contrast. Markedness is inherently a relative concept, i.e. a marked linguistic element is not ill-formed per se, but only in comparison with other linguistic elements. What is marked and unmarked for some structural distinction is not an arbitrary choice, but grounded in articulatory and perceptual systems. For example, oral vowels are unmarked in any language, and nasal vowels are marked – there is no language which has nasal vowels which does not also have oral vowels. Markedness is counterbalanced by faithfulness, which is a general requirement for linguistic forms to be realised as close as possible to their underlying forms. The function of faithfulness is to express contrasts. The conflict between markedness and faithfulness means that a language can be maximally faithful to meaningful sound contrasts only at the expense of an increase in phonological markedness. Conversely, a language can decrease phonological markedness only at the expense of sacrificing valuable means of expressing lexical contrast.

As previously stated, the syllable structure of Moloko is based on a CV pattern. The two markedness constraints from universal grammar which are significant to this analysis are as follows:

29a) ***COMPLEX** Only one consonant is permitted at a syllable edge

b) ***CODA** Syllables must not have codas.

Violations of *COMPLEX are fatal, except when one of the consonants is a liquid (refer section 3.1). The *CODA constraint may be non-fatally violated in Moloko in word-final position, therefore this constraint must be dominated to allow for closed syllables in that position.

30) *COMPLEX >> *CODA

The following tableaux examine the ranking of faithfulness and markedness constraints in Moloko. (The question of how many vowels should be specified in the input does not affect the results of this ranking, so for convenience the input selected is underspecified for the final vowel.)

31) Faithfulness constraints ranked higher than markedness constraints

Input **CVCC**	**FAITH**	***COMPLEX**	***CODA**
a) ☛ CVCC		*!	*
b) CVCVC	*!		*
c) CVC	*!		*

The optimal form selected in (31) has a complex coda, a form which is not attested in Moloko.

32) Markedness constraints ranked higher than faithfulness constraints

Input **CVCC**	***COMPLEX**	***CODA**	**FAITH**
a) CVCC	*!	*	
b) ☛ CVCVC		*	*
c) ☛ CVC		*	*

In (32), two forms are equally selected as optimal, one involving insertion of a vowel, and the other deletion of the final consonant. Since FAITH is included here as a simple catch-all requiring complete faithfulness from the input to the output, this result suggests that this constraint must be broken down in order to distinguish between these two violations. This will be discussed in the following section. Since the surface form attested in Moloko is in fact CVCVC (from (32)b, e.g. [harats] 'scorpion' and other examples from (2), section 2.3), this suggests that in Moloko syllabification, markedness is ranked higher than faithfulness.

33) Markedness >> Faithfulness

This case highlights the fact that inputs do not necessarily conform to the surface syllabification. The one-vowel hypothesis underspecifies all [-Low] vowels in the underlying form, which means that input structures may include strings with adjacent consonants, e.g. CCC. These sequences would normally surface with an appropriately placed epenthetic non-low vowel: CəCəC (or [i] or [u] if the word bears a prosody), which would involve violations of FAITH, considered in section 4.5.

4.4 Final vowel

As stated earlier (section 3.4), the final vowel in any Moloko lexical item ending in a closed syllable is always [+Low] before a pause and [-Low] in any other context. A further constraint is required to handle this variation. In this case, the constraint will be context-sensitive (cf. *COMPLEX which was context-free). As a markedness constraint, it will be ranked higher than FAITH.

34) ***V[-Low]C##** Vowels are always [+Low] in closed final syllables before a pause.

The ranking of this constraint in relation to FAITH gives the two possible outcomes dependent on context.

35) No crucial ranking between faithfulness and markedness constraints.

CəCəC	***COMPLEX**	***V[-Low]C##**	**FAITH**
a) CCC	**!*	*	*
b) ☛ CəCəC		*	
c) ☛ CəCaC			*
d) CəCC	*!	*	*

Ranking the markedness constraint higher than the faithfulness constraint gives the citation form with the [+Low] vowel in final syllable (as in 35c), while ranking the faithfulness constraint higher would give the context form with the [-Low] vowel in the final syllable (as in 35c). The examples given in the remainder of this paper will be given in citation form, which ensures consistency with the markedness/ faithfulness ranking given in (33).

The following tableaux use the example given previously (in 26, section 3.4), where two different forms underlie the identical surface form [tsar],[18] meaning 'taste good' with /a/ in the underlying form, and 'climb' with a [-Low] or underspecified vowel.

36) 'taste good' input: /tsar/

	***COMPLEX**	***V[-Low]C##**	**FAITH**
a) ☛ tsar			
b) tsər		*	*
c) tsr	*!	*	*

In this case, the optimal output form is completely faithful to the input form.

37) 'climb' with underspecified vowel in the input: /tsr/

	***COMPLEX**	***V[-Low]C##**	**FAITH**
a) ☛ tsar			*
b) tsər		*	*
c) tsr	*!	*	

[18] Recall that /ts/ functions as a single consonant in Moloko (refer 3.1), therefore *COMPLEX is not violated.

Here the optimal form is realised through the syllabification constraint forcing the insertion of a vowel, and the markedness constraint dictating the quality (height) of the inserted vowel.

For completeness, the underlying form from the two-vowel hypothesis is included.

38) 'climb' with [-Low] vowel in the input: /tsər/

	* COMPLEX	*V[-Low]C##	FAITH
a) ☛ tsar			*
b) tsər		*	
c) tsr	*!	*	*

Therefore, both underlying forms generate appropriate surface forms, and the lexical distinction between the words is maintained in the underlying forms (and conjugated forms, which will be examined later (section 4.7). The two different vowel hypotheses do not affect the outcome, since both with and without a final vowel posited, the correct optimal form is selected.

4.5 Correspondence Theory

Optimality Theory developed from work on Prosodic Morphology (for overview see McCarthy & Prince 1995). More recently, with specific reference to reduplication, McCarthy and Prince (1996, 1999) have proposed a variation on OT, known as Correspondence Theory, which rests on three of the fundamental ideas of OT (parallelism of constraint satisfaction, ranking of constraints, faithfulness between derivationally-related representations). Parallels were identified between base-reduplicant identity in reduplicative morphology and the requirements of input-output faithfulness in phonology. Uniting these two domains, they propose that candidate sets come from GEN with a correspondence function expressing the dependency of the output on the input (or the reduplicant on the base).

39) **Correspondence**: (McCarthy & Prince 1996:262)

> "Given two related strings S_1 and S_2 (input and output), Correspondence is a function *f* from any subset of elements of S_1 to S_2. Any element α of S_1 and any element β of S_2 are correspondents of one another if β is the image of α under Correspondence; that is, $\beta = f(\alpha)$."

Along with this notion of Correspondence, they propose that Universal Grammar includes various families of constraints on correspondent elements. The function EVAL considers each candidate pair S1, S2 and its Correspondence function, assessing the relation between S1 and S2 with respect to the constraints on Correspondence. Some examples of Correspondence constraint families include MAX, DEP and IDENT.

Constraints on correspondence are basically an extension of Faithfulness constraints in that they enforce fidelity of the output to the input. In perfect faithfulness, the output is identical to the input. In the case of Moloko, faithfulness will be violated in one of two ways, depending on what is selected as the input. McCarthy & Prince (1996) define the following constraint families:

i) **MAX:** every segment of S1 has a correspondent in S2 (S2 'maximises' S1). In MAX I-O, every segment of the input has a correspondent in the output, i.e. there can be no phonological deletion. If two vowels are posited for Moloko, then MAX is violated through deletion of [-Low] vowels in certain contexts.

ii) **DEP:** every segment of S2 has a correspondent in S1 (S2 is 'dependent' on S1). In DEP I-O, every segment of the output has a correspondent in the input, thus preventing phonological epenthesis. The one-vowel version of Moloko phonology violates this constraint since epenthesis is required by the syllabification rules.

iii) **IDENT (F):** correspondent segments must be featurally identical to one another. Crucial domination of one or more IDENT constraints leads to featural disparity and phonological alternation. This becomes important in Moloko when looking at vowels affected by the prosodies of palatalisation and labialisation (see section 4.7), but is also significant in considering the height of the final vowel.

The following tableaux examine the Moloko word for 'sheep.' According to the principle of 'Richness of the Base' (27 in section 4.2), five different inputs are posited, each one showing a variation on the one or two vowel hypothesis and the specification of the final vowel.

40)

Hypothesis	**Input**	**Final vowel**	**Tableau**
One-vowel	/tmk/	unspecified (absent)	(41)
	/tmak/	specified (present)	(42)
Two-vowel	/təmk/	unspecified	(43)
	/təmak/	specified [+Low]	(44)
	/təmək/	specified [-Low]	(45)

The constraints selected involve the difference between DEP and MAX, which are not crucially ordered (signified by the dotted line separating them) as they work independently. IDENT[LOW] must be ranked lower than DEP and MAX, since the identity of vowel height is not relevant if there is not vowel in the output. The *COMPLEX rule is maintained in order to rule out this redundant violation through the absence of the vowel. The interaction between IDENT[LOW] and *V[-Low]C## can also be seen in these tableaux.

41) One-vowel hypothesis, final vowel unspecified

/tmk/	***COMPLEX**	***V[-Low]C##**	**DEP IO**	**MAX IO**	**IDENT[LOW]**
a) tmk	*!!	*			*
b) tmak	*!		*		*
c) təmək		*	*		*
d) ☛ təmak			*		*

42) One-vowel hypothesis, final vowel specified

/tmak/	***COMPLEX**	***V[-Low] C##**	**DEP IO**	**MAX IO**	**IDENT[LOW]**
a) tmk	*!!	*		*	*
b) tmak	*!				
c) təmək		*	*		*
d) ☛ təmak			*		

43) Two vowel hypothesis, final vowel unspecified

/təmk/	*COMPLEX	*V[-Low]C##	DEP IO	MAX IO	IDENT[LOW]
a) tmk	*!!	*		*	*
b) tmak	*!			*	*
c) təmək		*	*		*
d) ☛ təmak			*		*

44) Two-vowel hypothesis, final vowel specified [+Low]

/təmak/	*COMPLEX	*V[-Low]C##	DEP IO	MAX IO	IDENT[LOW]
a) tmk	*!!	*		*	(*)
b) tmak	*!			*	
c) təmək		*			*
d) ☛ təmak					

45) Two-vowel hypothesis, final vowel specified [+Low]

/təmək/	*COMPLEX	*V[-Low]C##	DEP IO	MAX IO	IDENT[LOW]
a) tmk	*!!	*		*	*
b) tmak	*!			*	*
c) təmək		*			
d) ☛ təmak					*

Each of these tableaux gives the same result, that [təmak] is the optimal output irrespective of the nature of the input. Therefore some other principle is required to allow some distinction between the various inputs.

4.6 Lexicon Optimisation

OT is an output-based theory, expressing generalisations as interactions of constraints at the output level, never at the level of the input. According to the principle of "Richness of the Base," no specific property can be stated at the level of underlying representations.

The situation which has been established in this analysis of Moloko says that the output is known, and the optimal input is what is required. Fortunately, there is some allowance within OT for this situation, developed in consideration of learnability factors. In a case where the same phonetic form is obtained for multiple input representations, a principle known as Lexicon Optimisation will be employed by the language learner

46) **Lexicon Optimisation** (Prince & Smolensky 1993:191)

"Of several potential inputs whose outputs all converge on the same phonetic form, choose as the real input the one whose output is the most harmonic."

To implement this principle, information from different tableaux is consolidated in a 'tableau des tableaux' (Itô, Mester & Padgett 1995) to compare each of the winning outputs for harmonic status, each in relation to the corresponding input. Thus each of the five inputs for the lexeme 'sheep' (from 4.5 above) and their optimal outputs are entered into a new tableau, and the optimal input is identified.

(In this case, the constraints *COMPLEX and *V[-Low]C## are not required, as these were not violated by the optimal outputs.)

47) Tableau des tableaux for output [təmak]

	INPUT	OUTPUT	DEP IO	MAX IO	IDENT[LOW]
(41)	/tmk/	[təmak]	*		*
(42)	/tmak/	[təmak]	*		
(43)	/təmk/	[təmak]	*		*
(44) ☛	/təmak/	[təmak]			
(45)	/təmək/	[təmak]			*

The result which emerges from this tableau des tableaux is that the optimal input is the one which most closely corresponds to the output: /təmak/ -> [təmak]. The fewest violations are incurred where the vowel slots are specified (i.e. from the two-vowel theory), and the optimal result includes the specification of the height of the final vowel. Even though the faithfulness constraints (DEP, MAX and IDENT[LOW]) are not ranked highly, the result suggests that they still play an important determining role, which in turn favours the two-vowel theory of Moloko phonology.

4.7 Effects of prosody

So far the OT analysis has been focused on the central vowels, which are considered basic and do not bear any prosodic features. In this section, the analysis will be extended to examine words which include a prosody of either palatalisation or labialisation, which extends the surface vowel inventory of Moloko to include front and back vowels. A simple solution will be offered in the first instance, followed by a discussion of other possible approaches, which point to possible future directions for research.

As stated previously (section 2.3), the application of prosodies in central Chadic has features in common with vowel harmony systems, yet is quite distinct. Two of the most important differences are that the 'harmony' affects both vowels and consonants, and there is little evidence in Moloko that one vowel 'triggers' a harmony process, or that spread is directional (section 3.2). Traditional treatments of vowel harmony using Optimality Theory tend to rely on these factors, and therefore will not adequately account for this data .

OT focuses on the relationship between input and output representations. Having eliminated the prosodically marked vowels [i, e, o, u] from the underlying vowel inventory, it is necessary to characterise their presence in surface/output forms. The difficulty lies in the deviation from a faithful correspondence between input and output forms by virtue of the appearance of the prosody at a separate level of representation. A traditional generative approach could account for this by crucially ordered rules deriving the surface form from the underlying form. An autosegmental approach would distinguish separate tiers for segments, prosody, tone, etc., and their appropriate association lines. How then can a parallel OT approach account for these occurrences?

The principle of 'Richness of the Base' (from 27) requires that input representations are unconstrained, that the properties of outputs result from the effect of constraints on all lexical forms. One type of lexical idiosyncrasy is the inclusion in an input of unassociated featural material, such as tone, nasality, etc. In Chadic

languages, palatalisation and labialisation are unassociated features. Faithfulness imposes the requirement that a feature appear in the output exactly as in the input. For an unassociated feature, this would mean that if a feature was unassociated in the input, then it would remain unassociated in the output, thus preventing non-central vowels from being realised in the surface form of the language.

One account of this phenomena proposed by Pulleyblank (1997) involves constraints of the Link family preventing a feature from remaining unlinked. Whatever the status of a feature in the input, Link requires that the feature be associated to something in the output (in this case, the syllable). Violations of such a constraint would be fatal. The constraint which suits the Moloko situation can be defined as follows:

48) **LINK [PROSODY]:** a prosody must be associated with a syllable.

In order to account for words which have 'no' prosody, i.e. those realising only the central vowels, it is necessary to make explicit a 'zero-prosody.' Following the conventions of Chadic literature, the prosodies will be marked in the following way in the underlying/input forms:

49) / ^{y} CVCV/ palatalisation prosody
/ ^{w} CVCV/ labialisation prosody
/ $^{\varnothing}$ CVCV/ zero prosody

Inputs of this nature into the OT formalism would generate meaningless outputs (i.e. unpronounceable forms). In Moloko therefore, the association of the prosody with the syllable is more important than faithfulness to the input, thus requiring that LINK [PROSODY] outrank faithfulness constraints.

50) LINK [PROSODY] >> DEP IO, MAX IO >> IDENT[LOW]

Since the three prosodies in Moloko are in complementary distribution, it is not necessary to separate LINK into three separate constraints. Ranking of the constraints in this way would allow the outputs indicated in the following tableaux. (Since the number of vowels in the input does not affect the outcome, the inputs in these tableaux assume the one-vowel hypothesis.)

51) tableau showing palatalisation prosody for lexeme meaning 'sow'

	/^{y}ɮga/	***COMPLEX**	**LINK[PROSODY]**	**DEP IO**	**IDENT [LOW]**
a)	[ɮga]	*!	*		
b)	[ɮəga]		**!	*	
c)	[ɮge]	*!			
d) ☛	[ɮige]			*	

The following examples showing the labialisation prosody use the conjugated forms of the minimal pair examples given previously (section 3.4, ex.26). Violations of *COMPLEX are not fatal adjacent to liquids (section 4.3).

52) tableau showing 2nd person plural imperative form of 'climb'

/ʷtsram/		*COMPLEX	LINK[PROSODY]	DEP IO	IDENT[LOW]
a)	[tsram]	*	*!		
b)	[tsəram]		**!	*	
c)	[tsrom]	*			
d) ☛	[tsurom]			*	
e)	[tsorom]			*	*

53) tableau showing 2nd person plural imperative form of 'taste good'

/ʷtsaram/		*COMPLEX	LINK[PROSODY]	MAX IO	IDENT[LOW]
a)	[tsram]	*	*!	*	
b)	[tsəram]		**!		*
c)	[tsaram]		**!		
d)	[tsurom]				*
e) ☛	[tsorom]				

These results show how two different underlying forms generate distinct surface forms, differing only in the quality of the first vowel.

For completeness, a word with a zero-prosody is also included, in which the LINK constraint is unviolated, due to the greater correspondence between input and output.

54) tableau showing lexeme meaning 'sheep' (from 44) with zero prosody

/tmak/		*COMPLEX	LINK[PROSODY]	DEP IO	IDENT[LOW]
a)	tmk	**!		*	*
b)	tmak	*!			
c)	təmək			*	*
d) ☛	təmak			*	

From these tableaux it appears that the LINK constraint is sufficient to account for words affected by prosodies. A consideration of different accounts of harmony systems using OT offers a number of possibilities for the future directions of Chadic research.

The application of prosodies in Chadic may have more in common with systems such as nasal harmony, in which the feature [+nasal] affects certain segments but not others. In an overview of nasal harmony systems cross-linguistically, Walker (1999) observes that target segments may (a) become nasalised in nasal spreading, (b) remain oral while blocking nasal spreading, or (c) be transparent, remaining oral yet not blocking nasal spreading. A similar categorisation could be applied to Chadic prosodies in general, with specific languages selecting particular segments to fit into each of these classes (except blocking). Higi, for example, allows all consonants except [r] to be palatalised, and all but [l] to be labialised (Barreteau 1983). In Moloko, the target segments for palatalisation are vowels, alveolar sibilants and affricates, the targets for labialisation are vowels and velar consonants, while all other segments are transparent. Another way of saying this is that all vowels license prosodies, sibilants license palatalisation and velars license labialisation. An OT

representation could be established using a hierarchical typology, indicating a (language-specific) ranking of constraints along the following lines (based on Walker 1990):

55) *PALLIQUID >> *PALPLOSIVE >> *PALNASAL >> *PALSIBILANT >> *PALVOWEL

This segmental approach however fails to capture the significant generalisation that the prosodies affect the whole syllable, yet are only manifested on certain consonants.

An alternative to the Link constraint family is proposed by Yip (1996), who explicitly creates a family of Harmony constraints, which would apply to the Moloko data in the following way:

56) **PROSODY HARMONY:** All syllables must share any specification for labialisation or palatalisation.

This would keep the prosodies at the same 'level' as the individual segments, unlike the Link family which is conceptually closer to an auto-segmental approach. This constraint however would not account for realisations of non-central vowels which are not connected to a word-level prosody, such as those caused by assimilation adjacent to underlyingly labialised consonants or semi-vowels (refer section 3.2). Separate constraints are required for each of these as the assimilation applies differently in each case. An OT account would require markedness constraints forcing this assimilation, which would necessarily be ranked higher than the faithfulness constraints enforcing identity from input to output.

The issue of positional identity and neutralisation is used by Beckman (1996) to account for height harmony in the Shona language. Positional neutralisation rests on the idea that faithfulness can be more strictly enforced in some structural positions than in others, by means of highly-ranked position-sensitive identity constraints. Since the initial syllable triggers the height harmony in Shona, a higher premium must be placed on output correspondence in initial position than elsewhere in the word. In Moloko, the final syllable is the position most sensitive to neutralisation (section 3.4), yet unlike Shona, does not appear to function as a trigger for harmonic features. The Moloko system is not accounted for in her typology of height identity constraints and markedness rankings (Beckman 1996:67), however her analysis offers a possible line of future research.

Extensions to the model of Optimality Theory are suggested by Archangeli & Suzuki (1997) in their analysis of Yokuts phonology (specifically the areas of lowering, raising and harmony). They argue that correspondence can be extended to crucially non-identical elements, which makes faithfulness constraints a subclass of correspondence constraints. This accounts for the mismatch in vowel height between input and output in Yokuts: input long vowels are realised as non-high in the output, therefore the correspondence must be between length at one level of representation and height at the other, i.e. disparate correspondence. More significant to the present research, they argue against the OT principle that no restrictions of any kind may be imposed on the input. "However, if the markedness constraints are sensitive only to the output, it is impossible to account for a case in which output segments exist which are not part of the input inventory" (Archangeli & Suzuki 1997:207). They propose input markedness constraints which are inherently ranked below the corresponding output markedness constraint, so that they can figure only in Lexicon Optimisation. The possibility of constraints on input representations offers a

promising solution to the problem established in the present study, where vowels appear in the output which have no correspondent in the inventory of the input. Further research would be required to determine the nature and ranking of these input constraints, and to explore the notion of disparate correspondence in Moloko and other Chadic languages.

It is worth mentioning that the theory of Generalised Alignment (McCarthy & Prince 1993) is often used to account for this kind of patterning. The basic principle of alignment says that a designated edge of each prosodic or morphological constituent of a certain type must coincide with a designated edge of some other prosodic or morphological constituent. Pulleyblank (1997:90) summarises the Align family of constraints as requiring that the domain of a feature extend to the edge of a constituent, for example, the edge of the root or the word. Cases of 'harmony' or 'assimilation' result when morphemes introduce a feature that is subject to left- or right-edge constraints on its alignment. In Moloko, the domain of the prosody is generally restricted to the morpheme, with 'spreading' across boundaries in only a few cases (refer section 3.2 and Bow 1997c:32-33). Since the prosodies function as part of the lexical form, rather than being 'triggered' or directional, it is more difficult to make generalisations about edge phenomena at the level of the morpheme, without sub-categorising different types of morpheme. An analysis of Moloko morphophonology based on Alignment could open the door to a significant area of research. Unfortunately further analysis in this area is beyond the scope of the present work.

5. DISCUSSION & SUMMARY

5.1 One or two vowels?

Two hypotheses regarding the number of vowels in the underlying inventory of Moloko phonology have been examined from both a traditional derivational and an Optimality Theoretic viewpoint. Both hypotheses have been analysed as being able to account for the data, which leaves open the question of which hypothesis is to be preferred.

According to the one vowel hypothesis, schwa functions as an epenthetic vowel. It is absent from the underlying form of lexemes, and is realised at the surface level in order to break up disallowed consonant clusters. However its realisation at the surface phonetic level may be marked by the effects of prosodies, palatalisation [i] or labialisation [u]. To posit three separate epenthetic vowels would violate the principle of Lexical Minimality, yet if only one vowel can be epenthesised ([ə] being the least marked – refer 19) an additional process is required to account for its different realisations. A traditional generative analysis could account for this by the crucial ordering of rules, i.e. an epenthesis rule feeds a rule of prosodic effect. Without such a rule, only [ə] would ever be realised. The parallel approach of an OT analysis does not allow for rules to be ordered, thus feeding and bleeding processes must be handled in a different way, i.e. by the ranking of violable constraints. The present study indicates that such an analysis adequately accounts for the data according to both hypotheses, yet the different realisations of the non-central, non-low vowels suggests that if schwa were posited underlyingly, a single process (or constraint) could account for these prosodically-motivated allophonic realisations. Thus the process of palatalisation and labialisation of epenthesised vowels argues in favour of the two-vowel hypothesis.

The one-vowel hypothesis however is far from rejected by an OT analysis, which is able to account for the Moloko data according to both hypotheses. A number of different inputs with either one or two underlying vowels may be posited which all realise the same optimal output. Accordingly, the principle of Lexicon Optimisation offers a solution, by comparing the various inputs according to the constraint hierarchy, and selecting as the optimal input the one which has the fewest highly ranked constraint violations. Application of this principle to the Moloko data (section 4.6) supports a closer correspondence between the input and the output, which therefore argues in favour of the two-vowel hypothesis.

The issue of correspondence or faithfulness between input and output forms favours transparency in the relationship. The level of abstraction involved in the one-vowel hypothesis makes it fairly opaque. This hypothesis suggests that a contrast between two vowels can be accounted for by positing a single vowel in the underlying form which is then contrasted with its absence. This absence is then accounted for at the surface level with the appropriate epenthetic segment. It seems fundamentally simpler and more transparent to allow for two vowels to exist at an underlying level.

5.2 Other issues

Beyond the scope of the present analysis there are a number of different issues which may assist in determining the benefits of one hypothesis over the other. Four

of those issues are introduced here, each of which raise questions which cannot be answered in the context of this study, but suggest new avenues for further research.

i) **Typology**

Typologically, the existence of a language with a single underlying vowel would be highly unusual. Cross-linguistic analyses (e.g. Crothers 1978, Maddieson 1984) report that the minimum vocalic system involves a three-way contrast, i.e. a triangular /i, a, u/ system. Beyond Chadic, an analysis of certain Arandic languages (Breen 1977, see also Breen & Pensalfini 1999) has reduced the phonemic vowel inventory to two (/a/ and /ə/) or one plus length (/a/ and /a:/), with the short vowel influenced by the quality of adjacent consonants. If the issue of typology is allowed to encapsulate surface or phonetic forms, then the Moloko inventory with a more standard [i, e, ə, a, u, o] system allowing a full range of lexical contrast, fits in with standard typology. Strict typology of underlying forms would rule out both hypotheses offered in the present analysis.

ii) **Learnability**

Arguments relating to learnability factors can be used to argue for either one or two vowels. The tendency towards a more transparent relationship between input and output (the two-vowel hypothesis) could be considered useful to the learner, however the notion of linguistic parsimony, positing a minimal number of units in the underlying form (the one-vowel hypothesis), could also be considered to lighten the inventory load on the learner.

iii) **Orthography**

Issues of orthography, while having practical implications for the language community, do not appear to favour either hypothesis. An orthography with only one or two vowels would be both impractical and inadequate. The distinction between seven different vowel qualities, and the existence of minimal triplets such as those given in (10) and repeated here suggest that at least six vowels would be required.

57)	[kəra]	kəra	‘dog’
	[kire]	kire	‘stake/post’
	[k^{w}uro]	kuro	‘ten’

The other issue to consider in orthography development is the representation of the final vowel. In a lexicon or dictionary, the word in citation form should have the final vowel marked as [+Low], yet in basically all other contexts it will be pronounced as [-Low]. Extensive discussion and testing with native speakers of the language would be required to determine which course of action to take. Comparison with the writing systems of closely related languages would also prove beneficial.

iv) **Tone**

A possible alternative solution is suggested through a brief consideration of tone in Moloko.[19] Epenthetic vowels would normally be expected to copy a tone from elsewhere within the lexeme. The tone melodies of the language (Bow 1997c) make

[19] Transcription of tone from the author’s field notes is not reliable enough to make specific statements about the function of tone within the vowel system of the language.

it unclear whether the tone of [-Low] vowels is copied from elsewhere, or is simply manifested by the requirements of the tone melody, or is a distinctive element of the vowels themselves.

58) [bədzəgàmāy] ‘crawl’
[bìlĭmūwérék] ‘wild mango’

Detailed analysis of the tonal system may reveal two distinct types of [-Low] vowels: those which are phonemic and therefore carry tone underlyingly, and those which are epenthetic and copy tone from elsewhere.

5.3 Conclusion

This study has examined the vowel system of Moloko, in the context of analyses of Chadic vowel systems and Optimality Theory. The prosodies of palatalisation and labialisation and the specific vowel patterns associated with central Chadic languages account for the reduction from seven surface phonetic vowels to a much smaller system of underlying vowels. The morpheme-level prosodies have a lexical function, and expand the vowel inventory to include both front and rounded vowels. The vowel patterns, which in some cases may be linked to morphological processes, account for the realisation of the central vowels. Data from Moloko was examined using a traditional derivational analysis, from which two hypotheses were established to account for the vowel system of this language. Both hypotheses posit /a/ as phonemic, the one-vowel hypothesis contrasting this with the absence of this vowel in certain positions, the two-vowel hypothesis positing a second phonemic vowel /ə/. An Optimality Theory analysis based on the ranking of violable constraints explored these two hypotheses, in order to determine whether one or two underlying vowels was the optimal system for Moloko.

At the beginning of this thesis, it was mentioned that the approach taken to analysis and the level of abstraction selected could influence the outcome of an analysis. The approach taken here has shown that both hypotheses adequately account for the Moloko data according to both the traditional derivational and Optimality Theoretic viewpoints. The bias in favour of the two vowel system is due to the effects of prosodies on epenthesised vowels, the principle of Lexicon Optimisation, and the preference for a more transparent relationship between underlying and surface forms. Consideration of external factors such as typology, learnability and orthography could be argued in either direction, requiring further exploration. The differences between the two hypotheses appear in fact to come down to a question of which level of abstraction is selected. Further analysis of this type among other Chadic languages could shed more light on the situation. It is hoped that the present work offers a point of departure for further research in this complex and fascinating area of phonology.

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