A SIMPLE SCRIPT FOR BANGLA AND THE IPA MAPPING THEREOF

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Abstract: The conjuncts (or ligatures) are a fundamental issue for the Bangla (Bengali) script (or lipi), as it is for any other Brahmi script (e.g., Devanagari, Gujarati, Tamil, Kannada, Malayalam, etc). The conjuncts make the script unnecessarily complex and difficult to learn and to use. The conjuncts not only engender an exponentially large number of total characters for the script, but also render the character set to stay undefined and open ended. For example, one is unable to definitively answer the question, exactly how many conjunct characters are there in the Bangla script? By doing away with the conjuncts we not only make the script simpler, complete, and more elegant, but also open up a whole new world of opportunities where any complex sounding foreign word (e.g. words like Tsunami, Ptolemy, etc, which possess complex affricate sounds) can easily be imported or any new word can easily be coined and represented without redefining the character set of the script.

In this paper a complete script of a conjunct-free writing system of Bangla, named as Nobobangla, is presented. The alphabet set of the Nobobangla script and the rules to convert any Bangla word into Nobobangla format is described. Nobobangla is simple, direct, and easy to use in computing and in any other use. An efficient and easy-to-memorize mapping of the QWERTY keyboard for the Nobobangla characters is illustrated.

A phonetic analysis of the Nobobangla script is presented in this paper, for the richness and the completeness of its sounds. An exhaustive list of the Nobobangla phonemes are presented using the IPA (International Phonetic Alphabets) symbols. A number of example Nobobangla words are analyzed showing syllables, stresses, and phonemic pronunciations.

The concepts and the ideas of Nobobangla are equally applicable to other Brahmi scripts, as named earlier. In designing, developing, grouping and ordering the alphabets of the Nobobangla script, we put significant effort to make sure that each character (in both the vowel and the consonant tables, as illustrated below) has (or potentially has) a phonetically identical character in any Brahmi script (with 1:1 mapping), though the artistic rendering of the character may be different for different Brahmi scripts. In other words, in our new simple and enhanced scripting proposal below, the Nobobangla character set generically represent the alphabet set of any Brahmi script, except the artistic rendering.

1. INTRODUCTION

Bangla alphabets, as that of other Indic languages, are derived from the Brahmi script (or *lipi*). Brahmi script is the ancestor of hundreds of languages predominantly used in the Indian sub-continent as well as in south-east and east Asia [1]. The majority of the scholars believe that the Brahmi script originated from the West-Semitic languages (like that of any other Indo-European language) and has been in use in our sub-continent starting at least from 500 BC. Among the descendants of the Brahmi script are the Bangla script (used in Bangla language, Assamese, Garo, Mundari, etc) and the Devanagari script (used in Hindi, Sanskrit, Nepali, Marathi, etc). The alphabet set of any of the language originating from the Brahmi script are very similar in phonetic sounds, positional order, and in various other features.

The writing systems that originated from the Brahmi script constitute of syllabic alphabets, also known as *abugida*. The consonants of these alphabet sets have an inherent vowel (e.g., o (/ɑ/) in Bangla and, a (/ə/) in Hindi) with them. The inherent vowel of the consonant can either be muted by means of a special diacritic (named as *hasanth or halanth*), or be superseded by attaching a separate vowel diacritic. The vowels can be used either as a diacritic to a consonant or as a separate letter, either at the beginning of a word or elsewhere. The diacritics representing a vowel may reside above, below, before, after, or on both sides of a consonant, and thus often being placed in a *non-progressive* sequence. Note that, in comparison with the syllabic scripts, the other major writing systems of the world are: a) Consonant-only alphabets (Arabic in abjad form, Hebrew, Samaritan, etc), b) Phonemic alphabets (Latin/Roman, Cyrillic, Runic, Coptic, etc) , c) Syllabary (Hiragana Japanese, Katakana Japanese, Cypriot, etc), d) Logographic (Chinese, Kanji Japanese, etc), and, e) Alternative or other writing systems (Braille, Moon, Morse code, etc) [2].

Like other Brahmi scripts, conjuncts (or ligatures) are used in Bangla whenever two or more consonants occur together and have no pronounced vowel in-between the adjacent consonants. Conjuncts are one of the major disadvantages of the Bangla script (and for other Brahmi scripts as well), making its written representation more complex. The conjunct characters generate a huge number of character symbols, making it difficult for a user to learn and use them efficiently in various usage, e.g., in computing applications. There are over nine hundred conjuncts in Bangla according to some experts, and theoretically it could be even more (though three to four hundred of the conjuncts are used more frequently than the others). In addition to the huge number, the lack of a fully defined set of conjuncts, mandates the script to remain open-ended and incomplete.

Due to the difficulties related to the use of conjuncts along with the non-progressive nature of the Bangla vowels, a number of fundamental computing aspects (e.g., indexing, sorting, database, optical character reading, speech to text and text to speech, etc) are still open issues, waiting to be resolved effectively. Even after more than two decades, since Bangla were first used in computer, there are no significant use of Bangla in our daily computing (e.g., programming languages, OSes, e-mail, database, office applications, web applications, banking applications, etc). Neither the business offices, nor the educational institutions are able to use Bangla effectively for their all computing purposes. Bangla computing are restrictively being used primarily in the areas of printing, publishing and documenting, though not in a very efficient manner. To use Bangla *effectively* in all spheres of computing, it is essential that its interface with the computer be very simple. Without the simplicity, the effective and mass application of Bangla in computing will continue to stay as a dream.

We found that there are two fundamental issues with the writing systems that originated from the Brahmi script: a) the inherent vowel with each consonant not allowing two or more adjacently (side by side) placed consonants to make a compound consonant sound together, and, b) the same diacritic not being able to be applied to two or more adjacent (side by side) consonants due to the non-progressive nature of the vowel diacritics (as the vowel diacritics are used above, below, before, after, or on both sides of a consonant). We identified that these two aspects (i.e., the syllabic use of consonants and the non-

progressive use of vowels), which are inherent in all the Brahmi scripts, are the fundamental flaws that mandate conjuncts. By resolving these two fundamental issues, the Bangla script (as well as any other Brahmi script) can be made very simple and systematic, without requiring any conjuncts.

In the Nobobangla proposal, the above mentioned issues of the Bangla script are addressed firstly by taking off the inherent vowel from the consonants, and secondly by making the vowels strictly progressive. Each of the Nobobangla vowels is represented by a single symbol, always being placed in a progressive manner after a consonant (or a group of consonants) that is (or are) affected by it. In Nobobangla the Bangla vowels are simplified by: a) reducing the number of vowels to 8, being aligned with the findings of many experts, as the basic vowel sounds of Bangla [3], and, b) adopting only the diacritic representations of the vowels as alphabets (which can be placed independently at the beginning of a word or elsewhere). Thus the Nobobangla script becomes fully alphabet based and progressive, requiring no conjuncts, as described in the sections below.

The Nobobangla script has only 48 alphabet symbols as compared to more than nine hundreds or so in Bangla, making Nobobangla much easier to learn and to use. Also note that, Nobobangla has a phonemic alphabet set (as there are no inherent vowel with the consonants), as compared to a syllabic alphabet set of Bangla.

In the sections below, we also provide a phonetic analysis of the sounds of the Nobobangla alphabets and words. An exhaustive mapping of the sounds, of Nobobangla vowels and consonants, into the IPA symbols and phonemes are presented in this paper as per our current research. The mapping appropriately applies for that of Bangla as well. There has been some work already done in this effort for Bangla, though the results so far have been either incomplete or non-authoritative.

A number of example Nobobangla words are analyzed in Section 8 and 9, showing syllables, stresses, and phonemic pronunciations. Each and every Nobobangla word must be analyzed in future with such linguistic characteristics to enhance the speed, conformity, and the aural cognition of our language.

2. THE BASIC VOWELS

As per the position of the tongue while pronouncing a vowel, the Nobobangla vowels are categorized in three different groups, a) front, b) back, and c) central. Table-1 shows the 8 basic vowels of the Nobobangla script, in their new groups and positional order. The 1st and the 2nd column of Table-1 shows the position of the tongue when a particular vowel is pronounced. The 3rd column shows the new positional order, which is important for sorting and indexing. The 4th column illustrates the written representation (or artistic rendering) of any vowel character. The 5th and the 6th columns show the names of the vowels in Nobobangla and in IPA (International Phonetic Alphabet [4][5]) respectively. (Note that the name and the phonetic sound of a Nobobangla vowel is the same, as shown in Table-1. By coining an additional beautiful name for each of the Nobobangla vowels may be convenient to teach them.) The 7th column of Table-1 shows the corresponding letter or diacritic form in Bangla for any particular vowel.

Instead of 23 vowel symbols (11 letter forms and 12 diacritic forms: অ, আ, ই, ঈ, উ, ঊ, ঋ, এ, ঐ, ও, ঔ, and, া, ি, ী, ু, ূ, ৃ, ে, ৈ, ো, ৌ, and, ্ and ং) used in Bangla, there are only 8 vowel characters in Nobobangla. The last vowel (ɛ), which is called a *schwa* in English, currently has no use as an alphabet in Bangla. Schwa is profusely used in Devanagari, and is the first character of the Devanagari alphabet set. Schwa is also very extensively used in English sounds, though not as an independent character. We placed the schwa in the Nobobangla vowel-set primarily for two reasons, a) to bring all the Brahmi scripts under a common table, and, b) to make sure its potential use in Nobobangla in

future as it is *the* neutral vowel. Schwa is pronounced effortlessly without any stress while keeping the tongue in the most neutral position.

The Nobobangla vowel alphabets, in general, resemble the corresponding diacritic forms in Bangla in many respects (4 of them being exactly the same), in an intention to keep the look and feel of the Nobobangla script as close as possible to that of Bangla. Each of the Nobobangla vowels is represented by a single symbol (and/or glyph) and is placed in a word as an individual character in a *progressive* manner. A Nobobangla vowel alphabet may reside in a word in three ways: a) at the beginning of a word (making an independent sound), b) after one or more consonants (being pronounced with one or more consonant sounds), and, c) after or before one or more vowels (generating diphthongs and long vowel sounds). When there are more than one consonant before a vowel in a Nobobangla word, the vowel affects all of those consonants. The example words in Table-1 show the usage of the Nobobangla vowels as compared to that of Bangla vowels and diacritics.

To represent the Nobobangla vowels, we chose the diacritic-style arts (ী, া, ি, র, ে, ী, ়, ᴱ), instead of the letter-style arts (e.g., অ, আ, ই, উ, এ, ও, অ্যা), primarily for two reasons. Firstly, using the diacritic-style arts make a word shorter in length and quicker to write (note that the a vowels happen to occur more frequently in words than the consonants), and secondly, using the diacritic-style arts seems to generate more clarity and less confusion in reading a word as compared to that of letter-style arts.

Table-1: Nobobangla vowels and their usage

Tongue Position (High=jaw close, Low=jaw open)		No.	Nobo bangla Vowel	Name of the Vowel		Same Vowel in Bangla (letter and diacritic)	Example word in Nobobangla	Example word in Bangla
				Using Nobobangla	Using IPA			
Front	High	1.	ি	ি	/i/	ই, ি	লিশ	ইলিশ
	Mid	2.	ে	ে	/e/	এ, ে	কেনশ, শয়ে	একুশ, শেষ
	Low	3.	়	়	/æ/	অ্যা, া	়ঙলী, বল্য়ক	অ্যাংলো, ব্ল্যাক,
	Low	4.	া	া	/a/	আ, া	াকাশ	আকাশ
Back	Low	5.	ী	ী	/ɑ/	অ	ীজাঁগাঁর	অজগর
	Mid (lip rounded)	6.	ী	ী	/o/	ও, ে া	ীল, গীলাকার	ওল, গোলাকার
	High (lip rounded)	7.	র	র	/u/	উ, ়	নকবন	উকুন
Central	Mid (neutral)	8.	ᴱ	ᴱ	/ə/	NA		

3. THE COMPOUND VOWELS

Table-2 shows the use of the compound vowels of Nobobangla. Compound vowels (as defined here) are formed when two or more Nobobangla vowels are used adjacently in a word. Compound vowels are different than the diphthongs, though there are a considerable overlap between them. Nobobangla diphthongs are dealt comprehensively in Section 8 below.

Table-2 also shows that the long vowels (ঈ, ঊ, ী, ়) of Bangla are represented by placing a corresponding Nobobangla vowel twice, side by side. It is done so only to maintain the legacy, otherwise placing even a

single vowel would have sufficed. A long vowel has no real implications on making the sound long, even though the name of the vowel itself may suggest so in Bangla. The long-ness of a sound (long monophthong) really depends on how the word is pronounced, rather than on how the word in written.

Table-2: The Compound vowels of Nobobangla

No.	Compound Vowels	Example word in Nobobangla	Example word in Bangla
1.	�াঁ	শাঁশিাঁব, ারিরাঁবত	শৈশব, ঐরাবত
2.	াঁৱ	বাঁৱ	বউ
3.	াঁী	রাঁশান	রওশান
4.	াঁ	পাঁকিারা	পাইকারি
5.	াৱ	বাৱল	বাউল
6.	াঁা	াঁয়াজ	আওয়াজ
7.	ীা	নাঁদীা, াীগাঁল	নদী, ঈগল
8.	বি	টাঁবলাঁপ	টিউলিপ
9.	াঁী	কলাঁপটেরা	ক্লিওপেট্রা
10.	বা	পতৱশাক	পুঁইশাক
11.	বৱ	নবৱতাঁন, ৱবষা	নূতন, ঊষা
12.	াঁা	াঁমাতরাঁ	এইমাত্র
13.	বে	ঢবে	ঢেউ
14.	টা	কটাঁড়া	কেওড়া
15.	াৱ	মাঁৱমাছ্া, লাঁৱহাঁ	মৌমাছি, লৌহ
16.	য়ৱ	ন্যৱলা	ন্যাউলা
17.	াঁা	শ্যাঁলা	শ্যাওলা

4. THE CONSONANTS

Table-3 shows the consonants of the Nobobangla alphabet set being appropriately placed in groups and positional order. There are 40 consonants in Nobobangla, in 8 different groups. As shown, the characters in the Nobobangla consonant alphabet set follow a nice and easy-to-memorize logical as well as systematic progression, while being part of a close-knit and tight overall package. The consonants in the set are pretty much the same as it is in Bangla, with a few exceptions. Note that the consonants are no longer syllabic. The Nobobangla consonants no longer posses the inherent vowel sound /ɑ/ (অ) with them, rather it represents only the phonemic consonant part of the sound.

We believe that the pundit(s) who developed the original Brahmi script were more gifted for the consonants as compared to that of the vowels. The first 25 consonant characters (in 5 logical groups of velar, palatal, retroflex, dental, and labial), in all the Brahmi scripts, indicate the mental caliber of the pundit(s) of such ancient times. The order and the groupings of these 25 characters are kept unchanged in Nobobangla. The rest of the consonant alphabets in Nobobangla are reordered and bundled in 3 groups (each group containing four characters), while following a more theoretical and systematic approach. Beyond these 8 groups of consonants in Nobobangla, there are three additional consonants shown in Table-3 (i.e., ৎ, ং, and ঃ), which are redundant and not used at all in any Nobobangla application, as explained later in this section.

The names of the Nobobangla consonants are as shown in Table-3 (both in Nobobangla and in IPA). The names are the same as they are in Bangla, for the maximum of the consonants. The names of ণ, ন, য়, ঢ়, ষ, শ, স, and ড় are changed in Nobobangla, and now their names in effect represent their sound (though it is not necessary for an alphabet to have a name pertaining its sound), in an effort to help emphasize the difference in the sounds among the closely sounded alphabets. The name and the sound of ঢ় is different that of Bangla, it is an approximant (alveolar one), exactly like the sound of an English r, in an effort to enrich Nobobangla to gain authority over the English sounds. Also note the names and the sounds of জ /dʒɑ/ and য /zɑ/ are different in Nobobangla, the first one being an affricate sound and the latter one being a sibilant sound, in an effort to help enrich Nobobangla in phonetic sounds.

Two more significant differences between the Nobobangla and the Bangla consonant suites are: a) the *antastha bo* is given a new shape (ত) and name (/wɑ/) in Nobobangla, to separate it out explicitly from the *borgio bo* (ব), and, b) the letter *chandra bindu* is used in Nobobangla as an independent letter instead of as a diacritic to a consonant. One may notice that the nasalization influenced by *chandra bindu* happens with its adjacent vowel, rather than with its adjacent consonant, and such the placement of chandra bindu as a diacritic of a consonant in Bangla were not even linguistically justified.

Antastha bo (represented as ত in Nobobangla, and as ব in Bangla) and *antastha o* (য়) are semi-vowels, and they are phonetically similar to that of *w* and *y* respectively of the English alphabets. The use of য় in Bangla is often less palatal as compared to that of *y* in English, and *Antastha bo* in Bangla is used usually only with conjuncts (e.g., in ত্ক). Scope of these two semi-vowels are enhanced in Nobobangla, allowing both of them to be used independently, and even at the beginning of a word. The role of these two semi-vowels are enormous in pronouncing a huge number of foreign words which are now part of Bangla. For example, the word *weather* (ওদার) is pronounced in Bangla as it is in English even though we write it as ওয়েদার in Bangla, and similarly the word wicket (ত্কিকেট) is written in Bangla as উইকেট, though it is not pronounced as it is written in Bangla. The use of ত as an independent letter helps us write these words more precisely, as we pronounce them. Both the semi-vowels of *Antastha bo* and *antastha o* are present and used very dynamically in other Brahmi scripts (e.g., in Devanagari).

Table-3: Nobobangla consonants

Origin	Consonant No.	Nobobangla Consonants	Name of the Consonant		Example word in Nobobangla	Example word in Bangla or English
			Using Nobobangla	**Using IPA**		
Velar	1.	ক	কাঁ	/kɑ/	করষিক	কৃষক
	2.	খ	খাঁ	/xɑ/	খাঁরগাশ	খরগোশ
	3.	গ	গাঁ	/gɑ/	গরাহাঁ	গৃহ
	4.	ঘ	ঘাঁ	/ɣɑ/	ঘনড়াঁ	ঘুড়ি
	5.	ঙ	ঙাঁ	/ŋɑ/	ব্যঙ	ব্যাঙ
Palatal	6.	চ	চাঁ	/tʃɑ/	চাঁনদরাঁ	চন্দ্র
	7.	ছ	ছাঁ	/tʃʰɑ/	ছাতরাঁ	ছাত্র
	8.	জ	জাঁ	/dʒɑ/	জাঁঙগাঁল	জঙ্গল
	9.	ঝ	ঝাঁ	/d͡ʒʰɑ/	ঝাঁঞেঝাট	ঝঞ্ঝাট
	10.	ঞ	ঞাঁ	/ɲɑ/	লাঞেছাঁনা	লাঞ্ছনা

Retroflex	11.	ট	টাঁ	/ʈɑ/	ট্রাফ্কি	ট্রাফিক
	12.	ঠ	ঠাঁ	/ʈʰɑ/	ঠাণ্ডা	ঠাণ্ডা
	13.	ড	ডাঁ	/ɖɑ/	ডঙ্গেৱ	ডেঙ্গু
	14.	ঢ	ঢাঁ	/ɖʰɑ/	ঢোলাঁক	ঢোলক
	15.	ণ	ণাঁ	/ɳɑ/	বাঁৱণাঁ	বর্ণ
Dental	16.	ত	তাঁ	/t̪ɑ/	তৱাঁমাস্কি	ত্রৈমাসিক
	17.	থ	থাঁ	/θɑ/	থাপপাঁড়	থাপ্পড়
	18.	দ	দাঁ	/d̪ɑ/	দাঁকখঁণপাঁনথাঁৰ্ণ	দক্ষিণপন্থী
	19.	ধ	ধাঁ	/ð ʰɑ/	ধাঁননাঁবাদ	ধন্যবাদ
	20.	ন	নাঁ	/nɑ/	বাঁন	বন
Labial	21.	প	পাঁ	/pɑ/	পৱৱৱণাঁমা	পূর্ণিমা
	22.	ফ	ফাঁ	/ɸɑ/	ফৱিৱিঙ্গাঁ	ফিরিঙ্গি
	23.	ব	বাঁ	/bɑ/	বাঁঞ্চাঁনা	বঞ্চনা
	24.	ভ	ভাঁ	/βɑ/	ভৱৱসত্তাঁৱগাঁ	ভূস্বর্গ
	25.	ম	মাঁ	/mɑ/	মাঁসতৃষিকাঁ	মস্তিষ্ক
Approxima nt	26.	য়	য়াঁ	/jɑ/	য়াঁট, য়াহৱ	yacht, ইয়াহু
	27.	ঢ়	ঢ়াঁ	/ɹɑ/	কাঢ়ড	কার্ড
	28.	ল	লাঁ	/lɑ/	লাঁলাট	ললাট
	29.	ত	ত্তাঁ	/wɑ/	ত্বে, ত্বদোৱ	web, weather
Sibilant	30.	ষ	ষাঁ	/ʂɑ/	ষাঁষ্ঠাঁ	ষষ্ঠ
	31.	শ	শাঁ	/ʃɑ/	শাঁৱিষাঁসথান	শীর্ষস্থান
	32.	স	সাঁ	/sɑ/	সকৱল	স্কুল
	33.	য	যাঁ	/zɑ/	যৱকতাকখাঁৱ	যুক্তাক্ষর
Glottal, Rhotic, and Nasal accent	34.	হ	হাঁ	/hɑ/	হৱলসথৱল	হুলস্থুল
	35.	ড়	ড়াঁ	/ɽɑ/	বাৱ়াঁ	বাড়ি
	36.	র	রাঁ	/ɾɑ/	রাত	রাত
	37.	ত	চাঁনদৱাঁ বনিদৱ	/ˈtʃɑndrɔ ˈbɪndʊ/	চৱাঁদ	চাঁদ
(Redun dant)	38.	ৎ	তাঁ	/t̪ɑ/	হাঁঠাত	হঠাৎ
	39.	ং	ঙাঁ	/ŋɑ/	মাঙসাঁ	মাংস
	40.	ঃ	বসাঁৱঘাঁ	/bɪˈʃɑrɣɑ/	দৱকখাঁ	দুঃখ

It is not encouraged in Nobobangla to use, at all, the consonants of ৎ, ং, and, ঃ, even though they are placed in the alphabet set. The reasons behind forbidding the use of these consonants are: a) Nobobangla being non-syllabic, ৎ and ত are effectively the same consonant having the same phonetic sound, b) ঙ and ং have the exact same phonetic representation and one can be exchanged with the other, and, c) the letter ঃ has really no unique phonetic representation, one may simply omit it (e.g., ঁনতাঁঃসথাঁ -> ঁনতাঁসথাঁ) or can use another appropriate letter in place of it (e.g., দৱঃখাঁ -> দৱকখাঁ, নাঁঃসত্তাঁ -> নাঁহসত্তাঁ).

5. CONVERSION OF BANGLA WORDS INTO NOBOBANGLA SCRIPT

The generic rule of converting a Bangla word into the Nobobangla script is simple and straight forward. One just writes the corresponding vowels and consonants in an explicit and progressive manner in Nobobangla. As Nobobangla does not support any complex vowel or diphthong as a single alphabet, one

must break the Bangla alphabets, representing complex vowels, into the corresponding complex vowels of Nobobangla (e.g., Bangla, ৈ = Nobobangla, ীী). Given below are some corner case rules for example, applied in specific cases, when converting any Bangla word into Nobobangla format.

1. If any Bangla word has the character '𝗑' as its second or later letter, it is replaced by 'কখ' in Nobobangla, even if '𝗑' is an actual conjunct of 'ক+ষ' (e.g., পরীক্ষা/পাঁরিকখাঁ). If '𝗑' is the first letter of the Bangla word, it is replaced by only 'খ' in Nobobangla (e.g., ক্ষেত্র/খতেরাঁ).

2. If any Bangla word has the য diacritic (য-ফলা) with its second or later consonants, then in Nobobangla that consonant is placed twice, side by side, followed by the Nobobangla vowel ীঁ (e.g., সত্য/সাঁততাঁ).

3. If any Bangla word has the যা diacritic (য-ফলা এবং া-কার) with its second or later consonants, then in Nobobangla the consonant is placed twice, side by side, followed by the Nobobangla vowel ী (e.g., বন্যা/বাঁনন্য).

4. If any Bangla word has the য diacritic or the যা diacritic with the first consonant letter, then in Nobobangla the consonant is followed by the Nobobangla vowel ী (e.g., ব্যয়/ব্যয়, ন্যায়বান/ন্যয়বান).

5. If any Bangla word has a conjunct and one of the letter of the conjunct is the silent ব (*Antastha bo)*, then in Nobobangla the silent ব is changed into Nobobangla letter ত (e.g., ত্বক/তত্ৰাঁক).

Given below are couple of small paragraphs about a shrimp cooking recipe, to give the reader some idea about the look and feel of the Nobobangla script. Note that the art-work of the Nobobangla font, as shown here, is at the very initial stage of development. As there are only 48 symbols (and all individual alphabets) in Nobobangla, various fonts could be developed, with some research, having clarity as compared to that of English, even at the smallest font sizes. Note that in Nobobangla, each individual character font is easily represented by a single glyph, unlike that of Bangla.

চাঁঙড়াঁর মাঁলাঁকাঁরাঁ

বপাঁকাঁরাঁণ: চাঁঙড়াঁ মাছ- াঁধা কজোঁ, নারকলে বাটা- াঁধা কাপ, দবধ- ২ টবেলি চামাঁচ, াঁদা বাটা- ১ চা চামাঁচ, রাঁসবন বাটা- াঁধা চা চামাঁচ, ধাঁনপোতা কবচাঁ- ১ টবেলি চামাঁচ, কডাঁচা মাঁরাঁচ কবচাঁ- ১ টবেলি চামাঁচ, লাঁবাঁণ- পাঁরিমান মাঁতাঁ, শবকনা মাঁরাঁচ গডড়াঁ- াঁধা চা চামাঁচ, সাঁয়াবনি তলে- ৪ টবেলি চাঁমাঁচ, বাটার- ২ টবেলি চামাঁচ।

পরাঁসতবত পরাঁণাঁলাঁিঁ: চাঁঙড়াঁ মাছ লজে রখে কটে ধবয়ে নিন। পাতরাঁ চবলায় বাঁসয়ে পরাঁথাঁমে তলে, নারকলে বাটা, াঁদা বাটা, রাঁসবন বাটা, ধাঁনপোতা কবচাঁ, লাঁবাঁণ দিন, ীঁলপাঁ গাঁরাঁম পানা দিয়ে মাঁসলা কাঁষয়িে দবধটা দিন। বোর চাঁঙড়াঁ মাছগবলী দিন, কডাঁচা মাঁরাঁচ কবচাঁ দিন, ধাঁনপোতা কবচাঁ দিন, বাটার দিন। বোর দখেবনে কেটা বশে ভালী সবগাঁনধাঁ বরে হাঁবে। পাঁরিবশোঁন পাতরে নিয়ে সাজয়িে দিন।

6. THE KEYBOARD AND THE COMPUTER INTERFACE

Table-4 shows the keyboard mapping for the Nobobangla characters for an standard QWERTY keyboard. The mapping is intuitive and is as simple as it is in English. Nobobangla interface with the computer is direct. It uses only the standard English keyboard, and may not require any specific hardware or software keyboard mechanism. Nobobangla alphabets can even be designed to be fully based on the ASCII encoding. From the computing and usage point of view, Nobobangla has no less advantages in any way to that of English. Out of the 52 keys of the English alphabets (26 uppercase and 26 lowercase), 50 (8

vowels + 40 consonants + 2 special characters) are being currently used in Nobobangla, leaving 2 key spaces (A and Z) for any potential use in future. In Table-4 each cell represents one keypad, and the letter pair in each cell indicate which Nobobangla key corresponds to which QWERTY key.

Table-4: Nobobangla keyboard mapping

ি/i	ে/e	varies/x	া/a	ৎ/E	ঁ/q	ী/o	ব/u	।/L	৬/M
ক/k	খ/K	গ/g	ঘ/G	ঙ/Y	চ/c	ছ/C	জ/j	ঝ/J	ঞ/O
ট/t	ঠ/T	ড/d	ঢ/D	ণ/N	ত/v	থ/V	দ/f	ধ/F	ন/n
প/p	ফ/P	ব/b	ভ/B	ম/m	য/z	র/r	ল/l	ও/w	শ/S
ষ/X	স/s	হ/h	ড়/R	ঢ়/W	য়/y	ৎ/Q	ঃ/I	ঃ/H	ভ/U

7. THE PHONETIC ANALYSIS

Nobobangla is a conjunct-free and fully alphabet based script of Bangla. Phonetically or sound-wise, Nobobangla and Bangla are pretty much the same, except a few exceptions (e.g., the use of the semi-vowels ও and য in Nobobangla).

As in the case of any other languages, the orthography of a Nobobangla (or Bangla) word can not fully direct someone on how to pronounce (or read) it in a correct manner. One must know the pronunciation of a word in advance to utter it right. The orthography may merely guide someone towards the neighborhood of the right pronunciation.

IPA symbols are widely used, in dictionaries and in many other purposes, to indicate the correct pronunciation of a word of any language. Each symbol (or character) of IPA has a unique sound associated, generated by a pre-defined vocal articulation mechanism. By putting together the appropriate IPA symbols, the phonemic (in a broader sense) or the phonetic (in a narrower sense, e.g., the pronunciation of a word in a particular dialect) sounds of any word of a language can easily be represented. Even though IPA is still evolving, over a period of last more than hundred years it has captured the speech sounds and the articulation mechanisms of pretty much all the significant languages of the world.

The accurate mapping of the alphabets and the words of any language into IPA characters and symbols are of major importance. The speed, conformity, and elegance of a language can be enhanced and streamlined, by appropriately and exhaustively mapping its words in IPA, and thus by establishing an accurate guidance to pronounce all the sounds of that language. IPA is also widely used for processing speech in computing.

To map the Nobobangla sounds to the IPA symbols, the policies that were adopted are: a) analyze the uttered sound of a Nobobangla phoneme and try to find a symbol of it in the IPA chart, b) try to map the similar sounding Nobobangla phonemes as separate as possible in the chart, and c) keep in mind that in general the Nobobangla speakers are overall familiar with the English phonemic sounds (English is a compulsory school subject both in Bangladesh and in West Bengal). Also mentionable is the fact that, many of the Nobobangla speakers are familiar with the Arabic phonemic sounds, primarily for religious reasons.

The rhythm and speed of a language enormously depends on the stresses and the feet of the words. Stresses and feet are among the key elements of the sounds of the words. The stresses at the stronger syllables of the words, excites the listener to relate it to its meaning (stored somewhere in his brain) in a

quicker fashion [6]. Like English, the stressed syllable in a Nobobangla (or Bangla) word could be any syllable (the1[st], 2nd, 3rd, or 4th etc of the word), based on the sound of the word. Bangla is unlike many other languages where the stress location is fixed for all the words (e.g., in Finnish the stress is always at the first syllable of any word). We present below for the first time, to our knowledge, the analysis of some example Nobobangla words in syllables and stresses and provide the phonemic representations (or pronunciations) thereof.

Some of the linguistic analyses are easier to be done on the Nobobangla script as compared to that of Bangla, as there are no conjuncts involved and as the vowels are always progressive. As an example, one can easily show the individual syllables of a Nobobangla word by placing dots appropriately in that word (e.g., তি.ত্য.দা), as is the custom in the linguistic discipline.

We considered only *cholti bhasha* dialect for all the analysis and examples below, as *shadhu bhasha* dialect is rarely used anywhere now a days.

The reader is referred to [4], [5], [6], [7], and [8] for the online web materials related to IPA charts, symbols, fonts, and the audio sounds. Reference [9] has quite a significant amount of archive of the sounds of many languages of the world. For the convenience of the reader, we also provide here in the appendix, a visual IPA chart and a pictorial illustration of the human vocal tract components, which are important in speech sound production and articulation.

In the Sections 8 and 9 below, the terms 'Nobobangla' and 'Bangla' can often be used interchangeably. The phonetic descriptions presented here applies for Bangla as well, in general, except for some specific cases (e.g., the use of semi-vowel of ও).

8. PHONEMIC REPRESENTATION OF THE VOWEL SOUNDS

Table-5 illustrates the complete list of the phonemic representations of the Nobobangla vowel sounds. There are two types of Nobobangla vowels, monophthongs and diphthongs. Monophthongs are of two types, short and long. There are 8 short vowels (corresponding to 8 vowel alphabets of Nobobangla), 3 long vowels, and 19 diphthongs, as shown in Table-5. Among the short monophthongs, there is a *schwa* (/ə/) which corresponds to the sound of the Nobobangla vowel alphabet এ . Schwa is a mid central vowel and usually resides with the unstressed syllable. Schwa is prevalent in the sounds of the Devanagari and the English words, as we mentioned earlier.

The *obisruto o* (which is the first vowel sound in the word নদী) is not shown as a separate sound in the list below, rather it is mapped as /o/. The exact sound of the *obisruto o* should have been /ɔ̹/, a more rounded version of the IPA symbol /ɔ/. To keep all the basic Nobobangla vowel sounds simple and directly mappable from the vowel alphabets, we allowed no additional short monophthongs other than those which correspond to 8 Nobobangla vowel alphabets. All the Nobobangla vowel sounds are very intuitively mappable from the Nobobangla text. In other words, the phoneme follows the grapheme very tightly in Nobobangla. This is unlike that of English, where any of the vowel alphabets has multiple sounds (including short and long monophthongs as well as diphthongs), and one must memorize in advance which sound to apply in place of a particular vowel in a given word.

All the Nobobangla vowel sounds, including the diphthongs, can be understood closely by studying each row of the Table-5. For each of the vowel sounds, we present two example words and their corresponding phonemic representations, where that particular sound is used. The first word is primarily to show the

contrast (among the vowel sounds), and the second word is for further elaboration. If a word is made of multiple syllables, we show them explicitly by dividing the adjacent syllables by a dot (/./).

Note that, one of the important aspects of the phonemic representation of words, are the stress marks. A stressed syllable is one that is pronounced with more energy than an unstressed one. If a word is of single syllable, there are no stress marks required for that word. But if a word is made of multiple syllables, there may be one or two stresses attached to the sound of the word. In a multiple syllable word if only one syllable is stressed, the primary stress (/'/) mark is used, and when the word has two stress locations, one must be a primary stress and the other must be a secondary stress (/ˌ/). One must read carefully the phonemic representations of the example words given below, and may refer to the IPA chart in the appendix or [4], [5] and [6] for more clarification.

Table-5 also shows how a word is phonemically represented when it has a nasal sound attached, due to the presence of the letter *chandra bindu*. The vowel phoneme which is most adjacent to *chandra bindu* is shown as nasalized, by putting the Nasalized diacritic (/˜/) on top of that phoneme.

To compare the vowel sounds of Nobobangla with that of English, one should note that the different dialects of English (e.g., US, British, Australian, etc) has a different set of vowel sounds and diphthongs. In general, it can safely be said that Nobobangla has more vowel sounds (including the diphthongs) in number (31 shown in Table-5 as compared to 24 in British English and 15 in American English [9]), though English has several unique vowel sounds (especially the rhoticized ones) which are not available in Nobobangla. The Nobobangla vowels can be nasalized (being affected by *chandra bindu*), which does not exist in case of English.

Table-5: The Phonemic symbols of the Nobobangla vowel sounds

		No.	Phonemic sounds	Example words	Phonemic representations
Monopthongs	Short vowels	1.	/ɪ/	বলি, তি.ত্য.দি	/bɪl/, /ˈɪt̪t̪æd̪ɪ/
		2.	/e/	বলে, তে.তৰল	/bel/, /ˈt̪et̪ʊl/
		3.	/æ/	ব্যট, খে.লা	/bæt/, /ˈxælə/
		4.	/a/	বাম, সা.বান	/bam/, /ˈʃaban/
		5.	/ɑ/	বাঁল, খাঁট.কা	/bɑl/, /ˈxɑtka/
		6.	/o/	তিত.লা, নাঁদি	/ˈt̪ot̪la/, /nod̪ɪ/
		7.	/ʊ/	বৰন, সাঁ.বৰজ	/bʊn/, /ʃɔ̃ˈbʊdʒ/
		8.	/ə/	পে.টৱক, পৰে.সা.ডেনেট	/pəˈtʊk/, /ˈpresɪdənt/
	Long vowels	9.	/iː/	বিণা, মে.শিন	/ˈbiːna/, /məˈʃiːn/
		10.	/aː/	না, ৷.কাশ	/naː/, /aˈkaːʃ/
		11.	/uː/	সকৱল, সৱন.দাঁর	/skuːl/, /ˈʃuːnd̪ɔr/
Diphthongs		12.	/ɑɛ̆/	নাঁয়, শাঁয়.তান	/nɑɛ̆/, /ˈʃɑɛ̆t̪an/
		13.	/ɑo/	নাঁ, শাঁ.কাত	/nɑo/, /ˈʃɑokat̪/
		14.	/aɪ/	নাৰ, ফাৰ.নাল	/naɪ/, /ˈɸaɪnəl/
		15.	/aɛ̆/	নায়, জায়.গা	/naɛ̆/, /ˈdʒaɛ̆gə/
		16.	/ao/	নাঁ, হাঁ.লাত	/nao/, /ˈhaolat̪/
		17.	/aʊ/	লাৱ, হাৱ.কাৱ	/laʊ/, /ˈhaʊˌkaʊ/
		18.	/ɪʊ/	নৰি, ভৰি.কাৰড	/nɪʊ/, /ˈβɪʊkaɹd/
		19.	/ʊɪ/	নৰৰ, দৱা.ধাৰ	/nʊɪ/, /ˈd̪ʊɪðʰaɾ/
		20.	/eɪ/	নৰা, বৰা.মান	/neɪ/, /ˈbeɪman/

	21.	/ea/	নয়ো, কয়োমাঁত	/nea/, /ˈkeamɑt̪/
	22.	/eo/	কেটা	/keo/
	23.	/eʊ/	কেৱে, ভেৱে.ভেৱে	/keʊ/, /ˈβeʊˌβeʊ/
	24.	/oɪ/	কাঁৱা, বাঁৱা.শাখ	/koɪ/, /ˈboɪʃax/
	25.	/oĕ/	শীয়	/ʃoĕ/
	26.	/oʊ/	বাঁৱ, চৱ.কৱা.দাৱ	/boʊ/, /ˈtʃoʊkɪˌd̪aɾ/
	27.	/oŏ/	শীী	/ʃoŏ/
	28.	/æĕ/	ন্য়য়, ঁন.নয়য়	/næĕ/, /ə̯ˈnnæĕ/
	29.	/æo/	ন্যো, শ্যা.লা	/næo/, /ˈʃæola/
	30.	/æʊ/	ন্যৱ.লা	/ˈnæʊla/
Nasalization of vowels	31.	/˜./	দঁাত, পঁৱা.শাক	/d̪ā̃t̪/, /ˈpõɪʃak/

Many of the Nobobangla words may apparently sound like having a diphthong, though in reality that is not the case. For example the words হঁায়ে /hɔ̃je/, বয়িয়ে /bɪje/, কৱয়ো /kʊwo/, নয়িঁাত /nɪjɑ̃t̪/, and মোয়া /mowa/ all have only monopthongs, though each of them may sound like having a diphthong.

9. PHONEMIC REPRESENTATION OF THE CONSONANT SOUNDS

Table-6 illustrates the complete list of the phonemic representations of the Nobobangla consonant sounds. For each of the consonant sounds, we present two example words (along with their phonemic representations), where that particular sound is used. The first word is primarily to show the contrast (among the consonant sounds), and the second word is for more elaboration.

We have a total of 36 consonant phonemes in Nobobangla. Among them are 10 plosives (/p/, /b/, /t̪/, /d̪/, /t/, /d/, /t̪ʰ/, /d̪ʰ/, /k/, /g/), 5 nasals (/m/, /n/, /ɳ/, /ɲ/, /ŋ/), 2 taps or flaps (/ɾ/, /ɽ/), 11 fricatives (/ɸ/, /β/, /θ/, /ðʰ/, /s/, /z/, /ʃ/, /ʂ/, /x/, /ɣ/, /h/), 4 approximants (/ɹ/, /j/, /w/, /l/), and 4 affricates (/tʃ/, /t͡ʃʰ/, /dʒ/, /d͡ʒʰ/). Each of the Nobobangla consonant alphabets has a direct mapping to only one of these 36 consonant phonemes, making the grapheme to phoneme mapping completely direct and unambiguous.

The voiceless plosives /t̪/ and /t/ are two separate phonemes in Nobobangla as it is apparent from the minimal pair words of /t̪al/ and /tal/, which are two separate words and pronounced differently. Similarly, the voiced plosives /d̪/ and /d/ are two separate phonemes in Nobobangla as it is apparent from the minimal pair words of /d̪an/ and /dan/, which are two separate words and pronounced differently.

Interesting to see that the alveolar approximant /ɹ/ (which is the sound of the English letter *r*) is part of the Nobobangla consonant sounds, as many of the English words are now part of Bangla. As we discussed earlier, the Nobobangla consonant ৰ is now dedicated for this alveolar approximant sound (i.e., /ɹ/).

The Nobobangla fricatives /ɸ/ (ফ) and /β/ (ভ) are bilabial, while the corresponding English fricatives are /f/ and /v/ which are labiodentals. /ɸ/ is audibly very close to /f/ and similarly, /β/ is audibly very close to /v/.

We believe that it is more practical to map the phonemic sounds corresponding to the Nobobangla consonants of ট and ড as alveolar plosives of /t/ and /d/, as opposed to retroflex plosives of /ʈ/ and /ɖ/ respectively. A student who learns the Bangla script must also learn the English language, and thus it is impractical for him to articulate two different phonemes for the English letter 't' and for the Nobobangla letter ট. Also we noticed that in many of the regions of our sub continent, ট and ড are already pronounced as alveolar plosive, like that of English letter 't' and 'd'.

The palatal approximants /j/ (য়) and the labial-velar approximants /w/ (ৱ), both of whom are also semi-vowels, are more dynamic in Nobobangla that it is in Bangla. In Nobobangla they can be placed at the beginning of a word, which were not the case in Bangla.

As stated above, there are 4 affricates in Nobobangla. Affricates in general are of complex articulation. The affricates of /tʃ/ (চ) and /dʒ/ (জ)are very common in many of the world's languages. An affricate starts with the sound of its first component (more often a plosive) and ends with the sound of its second component (more often a fricative). The other two affricates of the Nobobangla script, namely ছ ($\widehat{tʃ^h}$/) and ঝ ($\widehat{dʒ^h}$/), are the subject for further research, as we believe that they are pure affricates of some special kind, rather than just being the aspirated versions of চ (/tʃ/) and জ (/dʒ/).

To compare the Nobobangla consonant sounds with that of English, one can see that unlike the vowel sounds, the consonant sounds are the same across all the English dialects (e.g., US, British, Australian, etc). As shown in Table-2, there are 36 consonant sounds (or consonant phonemes) in Nobobangla as compared to 24 in English. Assuming that the sounds of /ɸ/, /β/, and /ð̪/ of Nobobangla are practically the same as /f/, /v/, and /ð/ respectively of English (from audible point of view as compared to the articulation point of view), there is only one English sound, namely /ʒ/ (as in, vision /ˈvɪʒn/, or measure /ˈmeʒəɹ/), which is absent from the Nobobangla phoneme set. On the other hand, Nobobangla has the additional phonemes or sounds of /ʈ/, /ʈ^h/, /ɖ^h/, /ŋ/, /ɲ/, /ɾ/, /ɽ/, /ð^h/, /ʂ/, /x/, /ɣ/, /$\widehat{tʃ^h}$/, and /$\widehat{dʒ^h}$/, which are not available in the English sounds. In Nobobangla, a phoneme never relates to a digraph or a trigraph, unlike English where a phoneme may often relate to a digraph (e.g., th /θ/, th /ð/, ch /tʃ/, sh /ʃ/, ng /ŋ/, etc) or a trigraph (e.g., sch /ʃ/ in British English).

Table-6: Phonemic symbols of the Nobobangla consonant sounds

Articulation stricture and place			No.	Phonemic symbol	Nobobangla words as example	Phonemic representations of the example words
Oral stops (or plosives)	Bilabial	Voiceless	1.	/p/	পল, পাত.লা	/pɪl/, /ˈpaʈla/
		Voiced	2.	/b/	বল, বাঙ.লা.দেশ	/bɪl/, /ˈbaŋla‚deʃ/
	Dental	voiceless	3.	/t̪/	তল, তা.রা.নাঁব.বাঁঁ	/t̪ɪl/, /ˈt̪ɪra‚nɔbbɔɪ/
		voiced	4.	/d̪/	দল, দৱ.রাঁ.তত্তাঁ	/d̪ɪl/, /d̪ʊˈratta/
	Alveolar	Voiceless	5.	/t/	টাল, টা.কা	/tal/, /ˈtaka/
		Voiced	6.	/d/	ডাল, ডাক.ঘাঁর	/dal/, /ˈdakɣɑr/
	Retroflex	Voiceless	7.	/ʈ^h/	ঠেলো, ঠাঁ.কা.না	/ʈ^hela/, /ʈ^hɪkana/
		Voiced	8.	/ɖ^h/	ঢাল, ঢাক.না	/ɖ^hal/, /ɖ^hakna/
	Velar	Voiceless	9.	/k/	কাল, কাঁ.লাঁ.রাঁব	/kal/, /ˈkalɔ‚rab/
		Voiced	10.	/g/	গাল, গাঁ.তা.নৱ.গাঁ.তিক	/gal/, /‚gɔʈanuˈgɔʈik/

Nasals (or nasal stops)	Bilabial		11.	/m/	মাল, মাত.রা.তা.রিক.তা	/mal/, /ˌmaˌraˌtɪˈrɪkˌtɔ/
	Dental		12.	/n/	নাল, নাঁ.জী.য়ান	/nal/, /ˈnɑoˌdʒowan/
	Retroflex		13.	/ɳ/	র্ণি, হাঁ.র্ণণ	/rɐɳ/, /hɔˈri:ɳ/
	Palatal		14.	/ɲ/	র্ঞ্ঞ, চাঁঞ.চাল	/ˈmɪɲə/, /ˈtʃaɲtʃal/
	Velar		15.	/ŋ/	ঠ্যঙ, গাঙ.চলি	/tʰæŋ/, /ˈgaŋtʃɪl/
Tap or Flap	voiced alveolar		16.	/ɾ/	রাত, রাজ.ধা.নর্ণি	/rɐt̪/, /ˈradʒˌðʰanɪ]
	Retroflex		17.	/ɽ/	হাড়, কর.ড়া	/haɽ/, /ˈkʊɽɪ/
Fricatives	Bilabial	Voiceless	18.	/ɸ/	ফাল, ফাল.তব	/ɸal/, /ˈɸalt̪u/
		Voiced	19.	/β/	ভাল, ভার.তকি	/βal/, /βout̪ik/
	Dental	Voiceless	20.	/θ/	থাল, নজ.বকে.সথান	/θal/, /ˈʊdʒbekˌsθan/
		Voiced	21.	/ðʰ/	ধাঁন, ধাঁ.নবক	/ðʰɑn/, /ðʰɔˈnu:k/
	Alveolar	Voiceless	22.	/s/	সথান, শরা.বাঁন	/sθan/, /ˈsrabɔn/
		Voiced	23.	/z/	যান.জাঁট, বা.জার	/ˈzanjɑt̪/, /baˈzar/
	Voiceless postalveolar		24.	/ʃ/	শাল, সা.তার	/ʃal/, /ˈʃat̪aɾ/
	Voiceless retroflex		25.	/ʂ/	ষাড়, মা.নবষ	/ʂaɽ/, /məˈnu:ʂ/
	Velar	Voiceless	26.	/x/	খান,খাঁচ.চাঁর	/xan/, /xɑtʃtʃɔɾ/
		Voiced	27.	/ɣ/	ঘাম, ঘাব.রা.নো	/ɣam/, /ˈɣabrano/
	Voiceless glottal		28.	/h/	হাল, হা.তা.হা.তা	/hal/, /ˈhaʈaˌhaʈɪ/
approximant	Voiced alveolar		29.	/ɹ/	কারড, সট্যান.ডারড	/kaɹd/, /ˈstændaɹd/
	Voiced palatal		30.	/j/	য়া.হব, দী.য়ে	/jaˈhu:/, /ˈdɪje/
	Voiced labial-velar		31.	/w/	দোয়া, তর্া.কটে	/d̪owa/, /ˈwɪkət/
	Voiced alveolar		32.	/l/	লাল, লবট.পাট	[lal], [ˈlʊtpat]
Affricates	Voiceless postalveolar		33.	/tʃ/	চাল, চাঁ.লা.চাঁল	[ˈtʃalə̩tʃal]
	Aspirated voiceless postalveolar		34.	/t͡ʃʰ/	ছাল, ছা.তরাঁ	/t͡ʃʰal/, /ˈt͡ʃʰaʈɾɔ/
	Voiced postalveolar		35.	/dʒ/	জাল, কা.জরে	/dʒal/, /kaˈdʒeɾ/
	Aspirated voiced postalveolar		36.	/d͡ʒʰ/	ঝাল, ঝাঁঞ.ঝাট	/ d͡ʒʰal/, /ˈd͡ʒʰɔn̩d͡ʒʰat/

The mappings of the Bangla (as well as Hindi) consonants to the IPA symbols as presented in [3] and [9], does not really express the real strengths and contrast of the sounds, as one would expect. Many of the phonemes, in these references, are placed so close (with only the difference of aspiration, e.g., the sounds of ক and খ as /k/ and /kʰ/, গ and ঘ as /g/ and /gʰ/, etc) that the contrast among the closest phoneme sounds are really not sufficient and accurate.

10. SUMMARY AND CONCLUSIONS

Conjunct characters are a major issue for any effective use of the script in learning, writing, computing, etc. Conjuncts force one to deal with a huge number of characters (e.g., over nine hundred in Bangla according to some experts), even when the basic alphabets are only a few dozens in number. In addition to the complexity in use, the lack of ability on exhaustively defining a complete set of all possible conjuncts, keeps any solution related to the Bangla (and similarly of any other Indic) script as incomplete and open ended.

Unlike the logographic or syllabary scripts, Bangla and other Brahmi scripts are inherently based on phonemic characters, like any European language. The origin or the root of the Indic scripts are the same as that of the European languages (and hence these languages are of the same family, known as the Indo-European group). We showed in this paper that by muting the inherent vowel sounds of the consonants and by making the vowels simpler and progressive, we can easily make the Bangla script (and similarly any other Brahmi script) very dynamic and easy for all usage. We presented here a complete solution of a conjunct free Bangla script, named as Nobobangla.

The use of Nobobangla is simple and dynamic, in many respects, as compared to that of Bangla. For example: a) In Nobobangla any letter can be connected with any other letter of the alphabet set, just by placing them side by side, b) Nobobangla provides elegant solutions to the issues of sorting, indexing, database, etc, c) Nobobangla has only 48 characters, making the solutions to OCR, speech to text and text to speech issues very simple, d) The interface of Nobobangla to computer is very simple and speedy, as it has a small number of characters fully mappable to ASCII, and, e) Nobobangla can easily and effectively be used by anyone in any computing environment and applications (e.g., in work, study, social life, etc) as its use is as simple as that of English in computer. One can easily be enabled to write programs like C, C++, or any other programming languages or operating systems (OSes) using Nobobangla.

We presented in this paper an alphabet set of 48 characters (with 8 vowels and 40 consonants), in a very well organized, scientific, and tightly packed manner. We redefined or added a few alphabets to the set to systemize, enrich, and simplify the phonetic capabilities of the script. The existing alphabet set of any Brahmi script are not as systematic as one would expect, especially in the vowel side. For example, the vowel diacritics are used in Bangla in a non-progressive manner, creating major issues in sorting, indexing, etc. Also a few of the diphthongs in Bangla are part of the vowel alphabet set (e.g., ৈ /oɪ/, ৗ /oʊ/) while the rest are not (e.g., /aɪ/, /eɪ/, /ao/, /ʊɪ/, /ɑo/, etc). These idiosyncrasies of a particular script are tolerable, but only to the extent until they are not a hindrance to the progress of the language it represents.

An exhaustive list of the vowel and the consonant phonemes of Nobobangla is presented in this paper, using the IPA symbols, as per the current results of our research. We linguistically analyzed a number of example words of Nobobangla to show syllables, stresses, and phonemic pronunciations. We have shown how to represent the nasalized sound due to the affection of a *chandra bindu,* and how to represent the vowel sound of *obisruto o.*

We indicated that further research is required to find the correct phonemes to represent some of the Nobobangla (or Bangla) sounds (e.g., of ছ, and ব) and possibly to find a few more diphthongs. A thorough research is required to analyze all the Nobobangla (or Bangla) words to ascertain their linguistic features (e.g., stresses, feet, phonemic representations, etc) to help establish a phonetic dictionary.

The linguistic analysis presented here, is the report out of the current status of our research on the accurate representation of the Nobobangla sounds. One of the prime objectives of this report were to entice individuals to make criticism and discussions on this effort, so the work can continue in the right direction.

The Nobobangla solutions, as we presented in this paper, apply in general for any other Brahmi language as well. We believe, it is inevitable for all the major Brahmi scripts to be more structured and to be free of conjuncts, for simplicity, more elegance, and computing ease.

11. ACKNOWLEDGEMENTS

12. REFERENCES

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Appendix A: The IPA Chart

THE INTERNATIONAL PHONETIC ALPHABET (revised to 1993, updated 1996)

CONSONANTS (PULMONIC)

	Bilabial	Labiodental	Dental	Alveolar	Postalveolar	Retroflex	Palatal	Velar	Uvular	Pharyngeal	Glottal
Plosive	p b			t d		ʈ ɖ	c ɟ	k ɡ	q ɢ		ʔ
Nasal	m	ɱ		n		ɳ	ɲ	ŋ	N		
Trill	ʙ			r					R		
Tap or Flap				ɾ		ɽ					
Fricative	ɸ β	f v	θ ð	s z	ʃ ʒ	ʂ ʐ	ç ʝ	x ɣ	χ ʁ	ħ ʕ	h ɦ
Lateral fricative				ɬ ɮ							
Approximant		ʋ		ɹ		ɻ	j	ɰ			
Lateral approximant				l		ɭ	ʎ	L			

Where symbols appear in pairs, the one to the right represents a voiced consonant. Shaded areas denote articulations judged impossible.

CONSONANTS (NON-PULMONIC)

Clicks		Voiced implosives		Ejectives	
ʘ	Bilabial	ɓ	Bilabial	ʼ	Examples:
ǀ	Dental	ɗ	Dental/alveolar	pʼ	Bilabial
ǃ	(Post)alveolar	ʄ	Palatal	tʼ	Dental/alveolar
ǂ	Palatoalveolar	ɠ	Velar	kʼ	Velar
ǁ	Alveolar lateral	ʛ	Uvular	sʼ	Alveolar fricative

OTHER SYMBOLS

- ʍ Voiceless labial-velar fricative
- w Voiced labial-velar approximant
- ɥ Voiced labial-palatal approximant
- ʜ Voiceless epiglottal fricative
- ʢ Voiced epiglottal fricative
- ʡ Epiglottal plosive
- ɕ ʑ Alveolo-palatal fricatives
- ɺ Alveolar lateral flap
- ɧ Simultaneous ʃ and x

Affricates and double articulations can be represented by two symbols joined by a tie bar if necessary. k͡p t͡s

VOWELS

Front   Central   Back

Close: i y — ɨ ʉ — ɯ u
ɪ ʏ   ʊ
Close-mid: e ø — ɘ ɵ — ɤ o
ə
Open-mid: ɛ œ — ɜ ɞ — ʌ ɔ
æ   ɐ
Open: a ɶ — ɑ ɒ
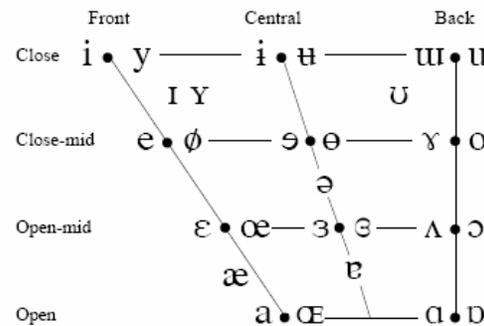
Where symbols appear in pairs, the one to the right represents a rounded vowel.

SUPRASEGMENTALS

- ˈ Primary stress
- ˌ Secondary stress
  ˌfoʊnəˈtɪʃən
- ː Long eː
- ˑ Half-long eˑ
- ˘ Extra-short ĕ
- | Minor (foot) group
- ‖ Major (intonation) group
- . Syllable break ɹi.ækt
- ‿ Linking (absence of a break)

DIACRITICS

Diacritics may be placed above a symbol with a descender, e.g. ŋ̊

̥	Voiceless	n̥ d̥	̤	Breathy voiced	b̤ a̤	̪ Dental	t̪ d̪
̬	Voiced	s̬ t̬	̰	Creaky voiced	b̰ a̰	̺ Apical	t̺ d̺
ʰ	Aspirated	tʰ dʰ	̼	Linguolabial	t̼ d̼	̻ Laminal	t̻ d̻
̹	More rounded	ɔ̹	ʷ	Labialized	tʷ dʷ	̃ Nasalized	ẽ
̜	Less rounded	ɔ̜	ʲ	Palatalized	tʲ dʲ	ⁿ Nasal release	dⁿ
̟	Advanced	u̟	ˠ	Velarized	tˠ dˠ	ˡ Lateral release	dˡ
̠	Retracted	e̠	ˤ	Pharyngealized	tˤ dˤ	̚ No audible release	d̚
̈	Centralized	ë	̴	Velarized or pharyngealized	ɫ		
̽	Mid-centralized	ě	̝	Raised	e̝	(ɹ̝ = voiced alveolar fricative)	
̩	Syllabic	n̩	̞	Lowered	e̞	(β̞ = voiced bilabial approximant)	
̯	Non-syllabic	e̯	̘	Advanced Tongue Root	e̘		
˞	Rhoticity	ɚ a˞	̙	Retracted Tongue Root	e̙		

TONES AND WORD ACCENTS

LEVEL			CONTOUR		
e̋ or	˥	Extra high	ě or	˩˥	Rising
é	˦	High	ê	˥˩	Falling
ē	˧	Mid	e᷄	˧˥	High rising
è	˨	Low	e᷅	˩˧	Low rising
ȅ	˩	Extra low	e᷈	˧˩˧	Rising-falling
ꜜ	Downstep		↗		Global rise
ꜛ	Upstep		↘		Global fall

Appendix B: An overview of the human vocal tract