Indus script deciphered: the method of semblance at work

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In this article we attempt to short-list the consonants present in the Indus script by analysing the bigrams of characters that form commutable pairs and to assign plausible phonemic values to select signs and words from the Indus text. We found semblance between all the fish-like signs that appear in the Indus writing with Kannada script. A one-to-one match among these signs helped discern the phonemic values of the characters involved. The Indus text was also found to be interlaced with numerical signs denoting higher-order numbers and fractions. A polynomial number system to the base 10 was in vogue to represent whole numbers and an hexadecimal number system employed for denoting fractional numbers. The concept of cardinal and ordinal numbers together with manipulating numbers involving addition, multiplication and exponentiation operations was known to the Indus people. It brings to light that the Indus civilization had reached great heights in numeracy. Also, indications appear that the Indus folk excelled in fine arts such as dance and music.

Keywords: Fish-like signs, Indus script, phonemic values, whole and fractional numbers.

WE believe that the Indian scripts belonging to Aryan and Dravidian family of languages must have evolved from the Indus writing. Although the inscriptional evidences for modern Indian language scripts appear around 1500 Years Before Present (ybp), one can presume that the writing system could have been in vogue prior to it for several thousand years. The orthographic peculiarities found in Indian language scripts to represent the medial-vowels and consonant-clusters can also be traced from the Indus writing. It is apparent that for writing purpose the Indus people must have employed the initial-vowels and consonants to begin with. The need to devise separate symbols for medial-vowels would have arisen in due course. Experimentation in orthography involving different notations for representing initial-vowels and their combination with consonants and consonant-clusters as observed from the Bryan Wells corpus (BW)[1] is depicted below.

V	*V_i			*CV_i				*CV_m	*CCV_i
a									
ā									
i									
ī									
u									
ū									

e									
ē									
ai									
o									
ō									
au									

*Signs appearing in the Bryan Wells corpus; V, Vowel; C, Consonant; V_i, Initial vowel; V_m, medial vowel.

Aksharas

The Indus text has been discerned to be a part-syllabic system of writing[2]. About 10 medial-vowel signs, namely , , , , , , , , , were identified. They seldom occur at the beginning position in the words. As a sequel, attention was drawn to read the phonemic values of other Indus signs. A novel strategy was employed to short-list the consonants present in the Indus text from the Indus sign pairs. The consonants invested with the inherent medial-vowel sign /a/ (akshara) do in general commute with each other. All the commutable pairs such as C_iC_j and C_jC_i were identified from the Indus bigrams. The subscripts i and j take values from 1 to 419, the terminal index being the number of distinct signs listed in the Iravatham Mahadevan (IM) corpus. An additional constraint was imposed on the constituent elements C_i and C_j that they should be followed by any one of the medial-vowel signs to the left and form bigrams of the type V_mC_i, V_nC_j. The subscripts m and n take values from 1 to 10, the terminal index being the number of medial-vowel signs

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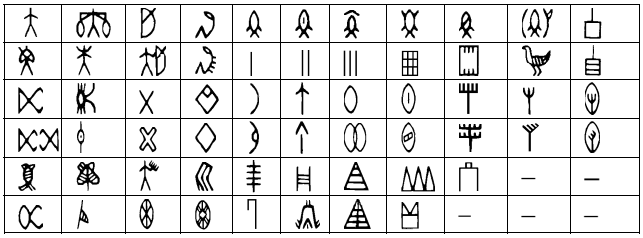
identified. This resulted in the following 61 Indus signs to be identified as the prospective candidates for aksharas from 419 signs listed in the IM corpus. They are:



The following one-letter and two-letter words found from the Indus text do encompass 43 out of the 61 aksharas listed above. They are:

This observation strengthens our conviction that the short text-bearing Indus seals were primarily intended to serve as teaching aids like the kindergarten flash-card material. The letter-by-letter word-building aspect of the beginner school-like material is also revealed by examining the following three-letter and four-letter words from Indus seals. They are:

An exercise of this kind if carried out for Tamil text yields the following characters to be identified as the likely candidates for aksharas.

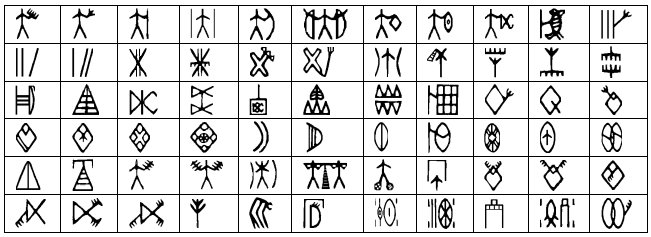
ka	ṅa	ca	ña	ṭa	ṇa	ta	na	pa
க	–	ச	ஞ	ட	ண	த	ந	ப
ma	ya	ra	la	va	ḷa	l̲a	r̲a	n̲a
ம	ய	ர	ல	வ	ழ	ள	ற	ன
k	ṅ	c	ñ	ṭ	ṇ	t	n	p
க்	ங்	ச்	ஞ்	ட்	ண்	த்	ந்	ப்
m	Y	r	l	v	ḷ	l̲	r̲	n̲

ம்	ய்	ர்	ல்	வ்	ழ்	ள்	ற்	ன்
ku	ṅu	cu	ñu	ṭu	ṇu	tu	nu	pu
கு	–	சு	–	டு	ணு	து	–	பு
mu	yu	ru	lu	vu	ḷu	l̲u	r̲u	n̲u
மு	யு	ரு	லு	வு	ழு	ளு	று	னு
a	i	u	e	h		ṭi		
அ	இ	உ	எ	ஃ		டி		
kū	tū	pū	mū	r̲ū		ṭī		
கூ	தூ	பூ	மூ	றூ		டீ		

This list besides consisting of aksharas also contains initial-vowels, basic consonants and conflated form of consonants with ukara and ūkāra medial-vowels.

Yuktāksharas

The basic consonant being mute and not regarded as an akshara, many of these signs combine among themselves and form conjunct consonants (yuktāksharas). We could identify conflated Indus signs that might stand for the yuktāksharas. They are:



The occurrence of bigrams such as  , ,  ,  ,  ,  ,  ,  ,  ,  in the Indus text indicates that they are the split form of consonant clusters such as ,  ,  , ,  , , ,  ,  , . Some of these clusters (yuktāksharas), namely , , , also accompany the medial-vowel signs or to the left. A significant number of the yuktāksharas in Kannada and Sanskrit either begin with the basic consonant ‘k’ or end up with the akshara ‘ya’. Instances of this kind appear in the Indus text as well: They are:

 (Indus text)

ಕ್ಷ, ಕ್ಕ, ಕ್ಟ, ಕ್ಡ, ಕ್ಕ, ಕ್ಲ, ಕ್ಮ, ಕ್ರ, ಕ್ಸ, ಕ್ವ, ಕ್ಯ (Kannada text)

 (Indus text)

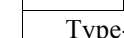
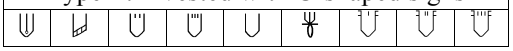
ಜ್ಯ, ಲ್ಯ, ಗ್ಯ, ಂ್ಯ, ಪ್ಯ, ದ್ಯ, ಷ್ಯ, ಥ್ಯ, ಹ್ಯ, ವ್ಯ, ಶ್ಯ,

ಣ್ಯ, ನ್ಯ, ತ್ಯ, ಜ್ಯ, ರ್ಯ, ಟ್ಯ, ವ್ಯ, ಢ್ಯ, ಠ್ಯ, ಕ್ಯ,

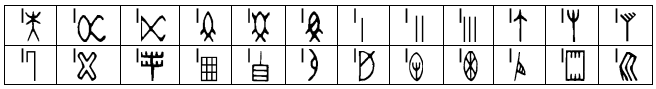
ಚ್ಯ, ಧ್ಯ, ಘ್ಯ, ಸ್ಯ, ಭ್ಯ (Kannada text)

Initial-vowels and basic consonants

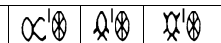
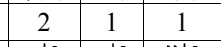
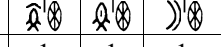
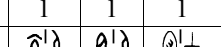
The commutable pairs from the Indus bigrams also indicate the presence of two kinds of intitial-vowel signs. They are:

Likely initial-vowel signs Type-1: invested with vertical stroke signs				
				
Type-2: invested with U-shaped signs				
				

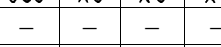
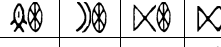
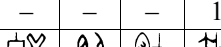
The Malayālam script employs the medial-vowel sign together with the short initial-vowel sign to denote the long initial-vowels, namely ī(ഇൗ), ū(ഉൗ), ai(ഐ), ō(ഒാ), au(ഔ). We could also figure out a notational system akin to Tamil that represents the basic consonants. From the consonantal symbol list, 24 signs were identified that are followed by a single vertical stroke sign to the left of the akshara. They are:



These could be construed as basic consonants. The yuktāksharas formed by these Tamil-like basic consonants found in the Indus text together with their occurrence frequency are depicted below:

								
1	2	1	1	1	1	1	1	1
								
1	1	1	1	1	1	1	1	1
								
1	2	1	1	10	1	1	1	4
								
1	1	1	1	2	1	1		

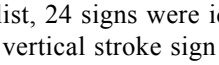
The bigrams obtained by eliminating the single vertical stroke sign from the above yuktāksharas seldom appear in the Indus text.

									
–	–	–	–	–	7	–	–	–	–
									
–	–	–	–	1	–	–	–	–	–
									
1	–	–	1	–	–	–	–	1	–
									
4	5	1	–	1	–	1			

The Tamil script also employs a notational system involving a ‘dot’ sign to indicate the basic consonant. This helps avoid ligaturing of consonants and makes the writing system simple. The commutable nature of an akshara with other aksharas is shown in Tables 1 and 2 for the Indus text and Tamil respectively.

Semblance of Indus fish signs with Kannada characters

It appears that the Tamil and Kannada scripts did not evolve from scratch, but owe their origin to the Indus script. We were able to read the phonemic values of all the fish-look like signs from the Indus text based on character semblance. The following six fish-like Indus signs culled out from the list of aksharas bear semblance with the Kannada script.



ವ, ಪ, ಮ, ಬ, ಷ, ಘ

They stand for consonant–vowels: va, pa, ma, ba, ṣa, gha. These six fish-like signs from the Indus text combine among themselves and form bigrams in 22 ways. Similarly, the phonemes ‘v/va, p/pa, m/ma, b/ba, ṣ/ṣa, gh/gha’ from the Kannada language form bigrams amongst them in 21 ways. The occurrence frequency is maximum for the pair ‘mb’ in the Kannada corpus and in the Indus text. This observation helps to uniquely fix the phoneme for ‘m’ and ‘b’. They correspond to the fish signs  and  respectively, in the Indus text. When two identical consonants follow each other in Kannada words, the shape of the second member changes. It either gets mutilated or takes a new form. However, the labial consonants ‘v’ and ‘b’ do not change in shape, but appear as subscript. This feature is also noticed in the Indus text and the pair of identical fish signs  found in the Indus text indicates that the symbol must correspond to the phoneme ‘va’ in Kannada. The sign pair corresponding to ‘bb’ does not appear in both the IM and BW corpora. However, there is a likelihood of its appearance in the artifacts yet to be unearthed.

In Kannada text, for the consonant–vowel combination involving the consonant ‘m’ and medial-vowel ī, the sign ೀ is appended to the conflated form involving the short medial-vowel i. It takes the form ಮೀ. However, an alternate form is also available for this labial consonant–vowel combination mī. It takes the form ಮಾ. Here instead of the ೀ sign, the medial-vowel sign ಾ is used. Such a feature is noticed in the BW corpus for the fish sign  . Here it takes the form  in addition to the normally used form . This observation is indicative of the fact that the fish symbol does belongs to labial consonants and the sign does in fact represent the

Table 1. Occurrence of inherent medial-vowel /a/ consonants with other aksharas (Indus text)

		1		4	11	2							1											
			1	6	3	3		1				1				1				6		1		
		2		7	5	4	5	67							7			1		2		3		
		16		11		3	5		2											8				
		7		7	28		1													12				
				1					1						2				4					1
		5		3	3	3			7					1		1		1		5	7	2		1
				1	1				7													1		
				9	3	1				1	1	1	2	1		1								
								1																
				6	1	2		8		10									1					
			1					6		2	8			1				2		2	1		2	
						1		10		4		2						1						
			1																					
		1		1	4	9	1		4		1							1		1	1			
			7						2	1			1			70		2					1	
								1			1						1				7		3	
							1						1					4						
				1										1		6			1				1	
				4	1	3	1		2								1		2					
	3		1	2				2	1		1						4	1			9			3
										1	5	1						2	2	1	1			1
				1	32	1		11										1						
								1							1		1		1					

Table 2. Occurrence of inherent medial-vowel /a/ consonants with other aksharas (Cangam Tamil)

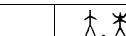
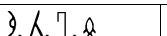
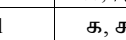
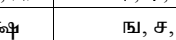
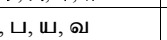
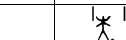
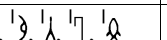
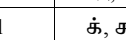
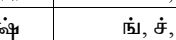
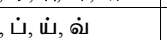
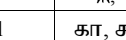
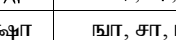
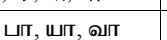
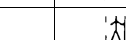
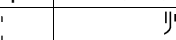
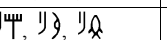
		ka	ṅa	ca	ña	ṭa	ṇa	ta	na	pa	ma	ya	ra	la	va	ḷa	ḻa	ṟa	ṉa
		க	ங	ச	ஞ	ட	ண	த	ந	ப	ம	ய	ர	ல	வ	ழ	ள	ற	ன
ka	க			3	20	756	118	103			299	153	136	449	292	237	228	82	125
ṅa	ங																		3
ca	ச	8									49	4	5	9	7				6
ña	ஞ										15		3	4					
ṭa	ட	26		1				5		1			21	28	136			1	79
ṇa	ண	2											23	6	41				2
ta	த	95		1		163	68	40		15	46	34	190	188	288	17	78	3	487
na	ந	148				33					59	207	91	296	1			66	101
pa	ப	304		142		515	8	103				256	417	610	97	185	1	93	35
ma	ம	645				450	400	94				185	366	609	1	60		322	43
ya	ய	20						3			12		77	101	115			22	11
ra	ர	7		71			36	48		1	17	3		47	118		7	4	
la	ல	153						3			61	3	46	5	151			16	5
va	வ	1		1		46	109	5	1		5	290	401	423	2	130	261	65	203
ḷa	ழ	13												18	96			10	42
ḻa	ள	4									9		21	4	48				1
ṟa	ற	5						8			6		1	22	191	15	2		112
ṉa	ன	9											2	10	136				

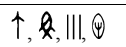
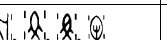
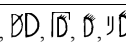
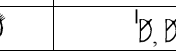
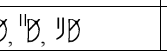
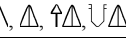
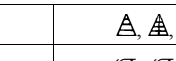
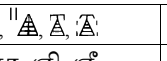
medial-vowel sign ā. The sign pairs and are found to occur in seals unearthed from the Mohenjodaro and Harappa (M&H) sites respectively.

Applicability of semblance method

We anticipated two consonant–vowels, namely 'pha' and 'bha' to get all the labial consonants. The 'pha' (ಫ) sign must be the undecorated form and derivable from the 'gha' (ಘ) sign. Likewise, the 'bha' (ಭ) sign must be the decorated form and derivable from the 'ba' (ಬ) sign. They are not found in the IM corpus, but show their presence in the BW corpus. This strengthens the applicability of the semblance method. The corresponding Indus signs for these consonants in the BW corpus are and . All these eight consonants readily combine with the medial-vowel sign ∪ to the left. The Indus signs , ; , bear

Table 3. Tamil-like semblance features found in the Indus text

c–a	Indus				
	Tamil	க, க்ஷ	ங, ச, ப, ய, வ	ஞ, ண, த, ந, ல, ற, ன	ட, ம, ர, ழ, ள
c	Indus				
	Tamil	க், க்ஷ்	ங், ச், ப், ய், வ்	ஞ், ண், த், ந், ல், ற், ன்	ட், ம், ர், ழ், ள்
c–ā	Indus				
	Tamil	கா, க்ஷா	ஙா, சா, பா, யா, வா	ஞா, ணா, தா, நா, லா, றா, னா	டா, மா, ரா, ழா, ளா
c–i	Indus				
	Tamil	க்ஷீ	ஙி, சி, பி, யி, வி	ஞி, ணி, தி, நி, லி, றி, னி	டி, மி, ரி, ழி, ளி
c–u	Indus				
	Tamil	கு	ங, சு, பு, யு, வு	ஞு, ணு, து, நு, லு, று, னு	டு, மு, ரு, ழு, ளு
c–ū	Indus				
	Tamil	கூ	ஙூ, சூ, பூ, யூ, வூ	ஞூ, ணூ, தூ, நூ, லூ, றூ, னூ	டூ, மூ, ரூ, ழூ, ளூ

c–a	c–ī	c–u	c–ū
Indus				
Tamil	ஸ, ஷ, ஜ, ஹ	க்ஷீ, வீ, ஷீ, ஹீ	ஸு, ஷு, ஜு, ஹு	ஸூ, ஜூ
Indus	ந, நங், நீ, நு, நூ	ங், ங, ஙா, ஙி	ஙெ, ஙே	ங்ங, ங்க, ங்கா
Tamil				
Indus				
Tamil	உ, எ, ஏ, ஐ	ஞ, ஞா, ஞி, ஞீ	ஞு, ஞூ, ஞெ	ச, சூ, ஜ, ஞ்ஜ, ஜு

c, Consonant; a, i, u, Short medial-vowel signs; ā, ī, ū, Long medial-vowel signs;  ~க,  ~ங,  ~ச,  ~ஞ.

semblance with the Kannada characters ನ-ನಿ, ನೀ; ಶ-ಶಿ, ಶೀ. The predominantly occurring terminal signs , , , found in the Indus text were identified to be the Kannada characters ಕಃ, ಕೆಃ, ಕೇಃ, ಗೆ, and whose phonemic values are 'kaḥ', 'keḥ', 'kēḥ' and 'ge' respectively. The heterogeneity of the ukara medial-vowel sign patterns found in the Tamil script and the homogeneity in labial consonant letter shapes in the Kannada script are worth studying. The semblance feature to the Indus signs is more noticeable in the case of Tamil and Kannada scripts than the Brahmi script[3]. The character semblance found between Indus signs with Tamil and Kannada scripts is shown in Tables 3 and 4.

Aspirated plosive signs from the Indus text

There are 10 plosive aspirated consonants present in the Kannada script. They have a short vertical stroke symbol attached at the bottom of a base sign that usually denotes the unaspirated form of the consonant. The following eight aspirated consonants from the Kannada script have the short vertical stroke sign at the bottom:

ಘ, ಛ, ಝ, ಢ, ಥ, ಧ, ಫ, ಭ

They correspond to the phonemes 'gh, ch, jh, ḍh, th, dh, ph, bh'. Occurrence of such signs with and without the short vertical stroke symbol attached at the bottom is found in the Indus text. Instances of this kind are listed below:

The occurrence frequency of aspirated consonants in Kannada and Telugu languages is much less, compared to the respective unaspirated consonant[4]. This feature is reflected in the Indus text as well. We contemplate that the above pairs must correspond to the unaspirated and aspirated form of the same consonant present in the Indus text.

The semi-vowel 'y' and spirant 'h'

The semi-vowel 'y' was identified from the Indus text for Tamil. Words beginning with any of the initial-vowel signs and followed by 'y'(ய்) are a common feature of Tamil. The occurrence of such a symbol was found in the Indus text. It

Table 4. Kannada-like semblance features found in the Indus text

Roman	p	Ph	b	bh	m	v	ṣ	pi	bi	mi	vi	ṣi	gh	ch	e	ē	ai
Kannada	ಪ	ಫ	ಬ	ಭ	ಮ	ವ	ಷ	ಪಿ	ಬಿ	ಮಿ	ವಿ	ಷಿ	ಘ	ಛ	ಎ	ಏ	ಐ
Indus-IM																	
Indus-BW																	
Brahmi																	
Roman	n	Ni	ś, śi	śī	t	th	d	dh	n	s	tm	km	ym	kaḥ	keḥ	kēḥ	ge
Kannada	ನ	ನಿ	ಶ,ಶಿ	ಶೀ	ತ	ಥ	ದ	ಧ	ನ	ಸ	ತ್ಮ	ಕ್ಮ	ಯ್ಮ	ಕಃ	ಕೆಃ	ಕೇಃ	ಗೆ
Indus																	
Roman	kaḥ	cḥ	ṭḥ	tḥ	ṭp	ṣv	vṣ	g	j	ḍ	d	b	kk	cc	ṭṭ	tt	vv
Kannada	ಕಃ	ಚಃ	ಟಃ	ತಃ	ಟ್ಪ	ಷ್ವ	ವ್ಷ	ಗ	ಜ	ಡ	ದ	ಬ	ಕ್ಕ	ಚ್ಚ	ಟ್ಟ	ತ್ತ	ವ್ವ
Indus																	

Consonants, k, g, gh, c, ch, j, ṭ, ḍ, t, th, d, dh, n, p, ph, b, bh, m, ś, ṣ, s, y, v; vowels, i, ī, e, ē, ai, aḥ.

is the trident sign and has an allograph too. This new sign has positional distribution in words similar to that of sign . They seldom occur at the beginning of words, but frequently appear at the medial and teminal positions in the words. These two signs do not appear simultaneously within the same line in the Indus text.

Likewise, the sign is the allograph for the sign . These two signs also do not appear simultaneously within the same line. They do not occur at terminal positions, but frequently appear at the initial and medial positions in the words. We have identified this sign to be the spirant 'h'. It has positional distribution in words similar to that of initial-vowel signs. Hence the two signs , stand for different phonemes. A set of people might have used the pair , and another set may have opted for usage of the pair , . To corroborate the above observation some representative lines taken from the Indus text have been depicted.

Seal nos 4646 and 5276:

Seal nos 5253 and 5230:

Seal nos 9091 and 1418:

Like the semi-vowel and spirant, the pair of signs {, }; {, }; {, }; {, }; {, }; {, , }; {, , }; also form allographs. There is a likelihood that the signs and belong to a language, say, Kannada, and and to another structurally similar language, say, Telugu, and have the same phonemic values.

Short-listing the consonants from the Indus text

Method-1

A plausible way to short-list the Tamil-like consonants present in the Indus script is the sign that appears to the right of signs , and . There are about 20 signs of this kind present in the IM corpus. They are:

The Tamil consonant list comprises 18 members only. Of this, 16 consonants can appear as doubles in word context. The signs that appear as doubles from this list are

Method 2

A method to short-list the Kannada-like consonants present in the Indus script is the sign that appears to the right of the bigrams and . There are about 28 signs of this kind present in the IM corpus. They are:

In addition to the above, five more signs appear in the BW corpus. They are: .

The phonemes that precede the medial-vowels 'o', 'ō', 'ai', from Kannada words are: k, g, gh, c, ch, j, ṭ, ṭh, ḍ, t, th, d, dh, n, p, ph, b, bh, m, y, r, l, v, ḷ, ś, ṣ, s, h.

These Kannada phonemes have to be mapped with the above Indus signs to arrive at the 'true' values for the consonants.

Method 3

A plausible way to short-list the Telugu-like consonants present in the Indus script is the sign that appears to the right of the bigram . There are about 19 signs of this kind present in the IM corpus.

They are:

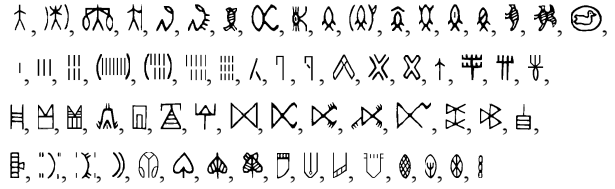
In addition, three more signs appear in the BW corpus. They are close to Mahadevan's listed signs:  ,  ,  .

Method 4

In the Indus text, there are signs decorated with short single vertical stroke symbol at four corners such as the fish-like signs . We have assigned the short 'i' value for these consonant–vowel signs based on the semblance method taking cue from the Kannada script. The signs that appear within this cage-like structure also qualify for the consonants present in the Indus script. There are about 20 signs of this kind present in the IM corpus. They are:

Method 5

The sign embedded between two medial-vowel signs of the type v1-c-v2 could also represent the consonant or conjunct consonant present in the Indus text. There are 66 such signs that appear in the IM corpus. They are:



An approach of this kind yields the following character list for Tamil.

Tamil (from Cangam treatise)

க, ச, ஞ, ட, ண, த, ந, ப, ம, ய, ர, ல, வ,
ழ, ள, ற, ன, கு, ஞு, டு, ணு, து, மு, யு, ரு, வு,
ழு, று, றூ, டி, அ, இ, க், ங், ச், ட், ண், த், ந்,
ப், ம், ய், ர், ல், ழ், ள், ற், ன்

An approach of this kind yields the following character list for Kannada.

Kannada (from the Kannada-Kasturi dictionary)

ಕ, ಖ, ಗ, ಚ, ಜ, ರ, ಟ, ಡ, ಣ, ತ, ಥ, ದ, ನ,
ಪ, ಬ, ಲ, ಶ, ಷ, ಸ, ಹ, ಳ,
ಕಿ, ಜಿ, ರಿ, ಟಿ, ಡಿ, ತಿ, ದಿ, ಬಿ, ವಿ, ಲಿ, ಶಿ, ಸಿ, ಹಿ,

ಛ್ಞ್ಡ್ಣ್ತ್ದ್ಷ್ಬ್ಳ್ ಭ್ ಲ್ ಶ್ಲ್ಞ್ವ್ಷ

From known to unknown phonemes

Having determined the phonemic values of the six fish-like symbols in the Indus script, the other phonemes can be deduced by looking at the bigrams for □, □, □, □, □, □ from the Indus text and character strings for v/va □, p/pa □, m/ma □, b/ba □, ṣ/ṣa □, gh/gha □ obtained from the Kannada dictionary. The Kannada-like consonants '□' obtained from Indus text are

The phonemes that follow 'v/va, p/pa, m/ma, b/ba, ṣ/ṣa, gh/gha' from Kannada words are: k, kh, g, gh, c, ch, j, jh, ṭ, ṭh, ḍ, ṇ, t, th, d, dh, n, p, b, bh, m, y, r, l, v, ḷ, ś, ṣ, s, h.

These Kannada phonemes have to be mapped with the above Indus signs to arrive at the 'true' value for the consonants.

Plausible phonemic values to the select signs and words from the Indus text

We have assigned the likely phonemic values to the consonants, conjunct consonants and words identified from the Indus text (Table 5).

A few Dravidian words with the following meanings have been identified from the Indus text. They are: you, she, brave, beauty, land, house, fruitfly, porcupine, owl, elephant and palmyra. It is likely that an error may creep in while associating phonemic values to the Indus signs and caution must be exercised as envisaged by Aurobindo[5] who says, 'Human intellect is always leaving old expression and symbol for new or, if it uses the old, it so changes its connotation or at least its content and

Table 5. Plausible values for Indus consonants and words

Consonants				Nasals	Conjunct consonants		Words
k	kh	g	gh	ṅ	ṅk	 kk	 nī, mane
 c	 ch	 j	 jh	 ñ	 ñj	 cc	 īya, ey
 ṭ	 ṭh	ḍ	 ḍh	 ṇ	ṇḍ	 ṭṭ	 aḷaku
 t	 th	d	dh	n	ntt	tt	āge
p	ph+	b	bh+	m	mb	mt	ille
y	r	l	v		yr	vv	gūge
ś	ṣ	s	h		yṟ	jj	gūbe
ḷ	ḷ	ṟ	kṣ		jñ		panē

+, Found in the BW corpus.

association that we can never be quite sure of understanding an ancient book precisely in the sense and spirit it bore to its contemporaries.'

Interpretation of text from the Indus seals

The typical size of the Indus seals is less than 1 inch in diameter[6]. The inscriptions generally appear above the animal motif. The line of text runs from the head of the animal along the back towards its tail[7]. The three Indus seals from Harappa shown here are worth studying (Figure 1). They contain words that are illustrated with figures as well. These words are composed of 2–4 signs representing initial-vowel (Indus sign [Indus sign]), medial-vowels (Indus signs [Indus sign] and [Indus sign]), nasal (Indus signs [Indus sign] and [Indus sign]) and labial (Indus sign [Indus sign]) consonants. We could read the text based on the semblance of Kannada characters with Indus signs. The first seal depicts the figure of an elephant. A text appears above the figure comprising two signs that are separated. They stand for the initial-vowel 'u' and the nasal consonant 'ṅ'. The word spells as 'uṅ' and stands for the meaning 'big' as understood in Tamil and Kannada languages. The two words that start with 'uṅ' in Tamil are 'uṅkuṇi' and 'uṅkāram', whose meanings are 'big oyster-shell' and 'roaring' respectively. There is a word in Kannada meaning 'big toe' and is spelt as 'uṅguṭa'. Hence to associate the word 'big' or 'roar' with the elephant as an adjective or verb seems to be right, and the text [Indus sign] depicted above the figure is pronounced as 'uṅ'. The word spelt as 'āne' to mean 'elephant' in Kannada language also appears as [Indus sign] in the BW corpus.

Indus writing

The second seal denotes the word 'nē' and acts as the terminating string in words. The third seal spells the word to be 'manē' denoting 'a land for cultivation' as understood in Tamil and Kannada languages. To illustrate this fact, a figure appears on top of the Indus text [Indus sign] showing a rectangular boundary within which a number of seedlings are planted in rows. The word spelt to be 'mane' to mean 'house' in Kannada language also appears in the Mohenjodaro text as [Indus sign].

Numerals

The stage of advancement of a civilization is also gauged by the sophistication of the languages used by it. Languages comprise of literacy and numeracy or quantitative literacy. In the case of the Indus text also, the authors have diligently searched for strings representing numerals, in the form of short vertical lines, necessarily not accompanied by other signs, to be the appropriate candidates. Five such signs were identified for the numbers 2, 3, 4, 7 and 9. They are: ||, |||, ||||, |||||||, |||||||||. These signs have been found to occur only at the Harappan sites. A combination of these signs with either [Indus sign] or [Indus sign] to the left also appears as text on many Indus seals from M&H. We believe that they represent numbers in multiples of 10. The basic cardinal numbers deducible from these are the following: |, ||, |||, ||||, |||||, [Indus sign], [Indus sign], [Indus sign], [Indus sign], [Indus sign]. Hence to ascertain if these signs represent numbers in addition to their role as initial-vowel signs needs further study. The astrologer vīmēcar uḷḷamudaiyān has rendered an astronomical table in the year 1234 describing the lunar position in celestial sphere using 248 sentences in Tamil[8]. He employed the Tamil medial vowel consonants from 'a' to 'ai' to represent numbers from 1 to 9, and the rest to indicate the number zero. The sentences encode a six-digit number for lunar positions expressed in units for zodiac numbers (0–11) and angles in degrees (0–29) and minutes (0–59).

We also attach special significance to the Harappan seals numbering about 250, in which text appears on one side and a few select signs are inscribed on the other. We believe that these signs represent numbers and could possibly be used as number tags for the seals (Figure 2). The signs that appear in the number tags are the following: |, ||, |||, ||||, [Indus sign], [Indus sign], [Indus sign], [Indus sign], [Indus sign]. These tags depict numbers 1–3 digits (signs) long. It transpires that a number system akin to that followed by ancient Tamils was in vogue during the Harappan era[9]. Here the number representation resembles a polynomial whose variable is the base of the number system[10]. The Harappans used the base 10 number system. Numbers ranging from 1 to 10, 100 and 1000 have been assigned unique symbols as follows: [Indus sign], ||, |||, ||||, [Indus sign], [Indus sign], [Indus sign], [Indus sign], [Indus sign], [Indus sign], [Indus sign], [Indus sign]. They bear semblance with Tamil numerals: ௧, ௨, ௩, ௪, ௫, ௬, ௭, ௮, ௯, ௰, ௱, ௲. The fish-like sign [Indus sign] with phonemic value 'va' is also used to denote the number 100 in Indus writing. The number 100 is verbally expressed as 'vanda' in Telugu. Perhaps the Indus people might have chosen the first letter of this word to represent the number 100. Likewise, the number 1000 is verbally expressed as 'sāvira' in Kannada. The first letter of this word lead us to assign the phonemic value 'sa' to the Indus sign [Indus sign]. It is also worth

Figure 1. Indus writings seals.

Figure 2. Indus numbers.

noting that the Tamils coined and handled special symbols for fractional measures as well[11].

We anticipated signs for the number 10,000 (ten thousand) from the Indus text that should be a combination of signs representing numbers 10 ( ) and 1000 ( ), and would appear as if read along the direction of writing, namely from right to left. To our surprise, we found such an occurrence in the 'Chanhudaro' text. The number 10,000 appears as . Instead of the anticipated three signs, it is depicted using only two signs in more compact form. About 15 such numbers were identified in the Harappan text. They are: , , , , , , , , , , , , and , . These numbers stand for values 2, 5, 6, 7, 8, 9, 15, 50, 80, 100, 405, 500, 900, 1000 and 10,000 respectively. The corresponding values written using Tamil numerals are: ௨, ௫, ௬, ௭, ௮, ௯, ௰௫, ௫௰, ௮௰, ௱, ௪௱௫, ௫௱, ௯௱, ௲, ௰௲. However, such an observation could not be made from the inscriptions available at Mohenjodaro.

The sign denoting the number 10 could also be split as two signs comprising and . Such usage has been found in the Grantha writing system[12]. Here the symbol ௰ or the Indus sign denoting the number 10 is alternatively written as 'க0' in Tamil using the two symbols 'க' and '0'. A semblance between this and the Indus representation leads one to assign values 1 and 0 respectively, to the Indus signs and . From this, it transpires that the Harappans were cognizant of the need to represent 'śūnya' or void symbol denoting zero. They indicated it with the presence of the symbol in numbers denoting 10, 1000 and 10,000. The advent of this technique simplified the numeral system and led to transition from polynomial to place value system, abandoning usage of numerals for 10, 100 and 1000.

The identification of signs for basic numerals has enabled us to read the values of any decimal number from the Indus writing. However, we do not know how to orally express these numbers. For instance, could be spelt as 'pattu', 'hattu' and 'daśa' respectively, in Tamil, Kannada and Sanskrit languages. There is an anomaly found between Tamil and Kannada languages in the articulation of numbers 90 and 900. In Tamil, they are spelt as if to sound like 'nine-hundred' (toṇṇūṟu) and 'nine-thousand' (toḷḷāyiram), and in Kannada 'nine-ten' (tombattu) and 'nine-hundred' (ombainūru). It appears that a separate symbol might have been employed in archaic Tamil to represent the number 900 if we assume that the numbers were written as they are verbally expressed. A scrutiny for such an occurrence from the Indus text was attempted. To our surprise, a sign was identified that could possibly denote the number 900. It is depicted as the symbol in Kalibangan text, and is the conflated form of the two signs and , representing the numbers 9 and 1000 respectively. However, the sign for the number nine appears within the diamond sign and hence the conflated sign would indicate the number 900. This antique feature suggests that Kalibangan could have been an earlier settlement of Indus people when compared to Harappa.

The coinage of the term for 900 in Tamil heralds the arrival of the number 1000 much in advance by hundred numbers. This impediment in counting numbers from 900 to 999 in Tamil seems to have been set right in archaic Kannada and the Kannada language evolved to a sophisticated level by augmenting voiced consonants, aspirates and sibilants. Caldwell[13] put forward his ideas on how to ascertain which language or dialect best represents the primitive Dravidian speech. The Indus sign indicating the number 900 could have been abandoned in later times in place of the alternate form . However, in Sanskrit the decimal numbers are verbally expressed from right to left and in this respect they differ from Dravidian tongues. We attach special significance to the conflated forms involving the sign for number 1000 and the sign for number 10. We read the value for the signs , , , , , , , , , to be 1,000, 2,000, 5,000, 9,000, 10,000, 10,000, 100,000, 100,000, 2,000,000 and 10,000,000 respectively. The signs , , stand for the numbers ten thousand (10×1000), one lakh or lakṣam ($10 \times 10 \times 1000$)) and one crore or kōṭi ($10 \times 1000 \times 1000$) respectively. The signs { , } could also be written as { , } to indicate the numbers 1000 and 2000 respectively. The first set seems to be redundant. However its presence can be justified if one takes into account the fact that these numbers can be articulated in two different ways as they appear in Tamil, namely, 'ōrāyiram' and 'īrāyiram' for the first set and 'oṉṟāyiram' and 'iraṇṭāyiram' for the second set. Verse 464 of the grammatical treatise *Tolkāppiyam*[14] substantiates this view by the following description: If āyiram is the following term, The /u/ of oru/oṉṟu and iru/iraṇṭu stands modified.

It is a great surprise that the Chinese too independently developed a number system based on 10 and expressed numbers using the polynomial form. The Chinese and Harappan civilizations are not contemporaneous. The decline of the Harappan civilization coincided with the ascension of the Chinese civilization. The timeline ascribed for Harappan civilization is between 5100 ybp and 3700 ybp, and for Chinese civilization between 3700 ybp and 3122 ybp. Hence there is a likelihood that the polynomial concept of expressing whole numbers might have percolated from the Indus region to China by the land route.

Singhalese-like numeral system

We understand the need for conflating of the sign (or) representing number 10 with the signs (or) representing number 1000 to generate higher-order numbers such as 10,000, 100,000 and 1,000,000. However, such a feature is not expected for signs that represent numbers 1 to

9 and 100. About a dozen signs that conflates with the sign (or) appear in the Indus text. They are:

These seem to represent numbers that are multiples of ten. The signs that one deduces by stripping-off the sign from the above conflated forms are the following: . These symbols indicate that an alternate number system was in existence in the Indus settlement, which is akin to the Singhalese number system[10]. The Singhalese assigned a separate sign not only to every power of ten, but also to each of the nine units and to each of the nine tens that formed a hybrid number system. The number 10 and conflated forms of ten for the numbers from 20 to 90 appear as follows in Singhalese: . The numbers 20, 30, 50, 80 and 90 get conflated in a particular way and 40, 60 and 70 in another way. We assign the value 1000 to the Indus sign that appears in the above list. This sign conflates with the sign in more than one way. These conflated signs appear as in the Indus text and could stand for the numbers 10,000, 100,000, 1,000,000 respectively. However, a unique sign representing the 'crore' was not traced in this numeral system and the largest number that appears in this list is 10 lakhs. Historians place in record the evolution of early Singhala–Brahmi[15] and Tamil–Brahmi scripts to be coeval and assign it to 2200 ybp.

Arabic	10, 20, 30, 40, 50, 60, 70, 80, 90
Indus	
Singhala	
Brahmi	
Kharosthi	

The Prakrit language also employed a hybrid number system as is evident from the numeral characters present for each of the nine tens and each of the nine units in Brāhmī and Kharōsthi scripts. However, the signs for the nine tens do not exhibit the conflating feature as found in the Indus and Singhalese scripts. This assimilation feature suggests that the Brāhmī script could not have been naturally evolved, but was invented under the patronage of a mighty ruler to satisfy the need of all language-speaking people. The retention of the conflating feature for numbers that are multiples of 10 in the Singhalese script drives home the conclusion that a separate script, possibly a descendant from the Indus script, would have been practised by Singhalese prior to the Mauryan era and the advent of the Brāhmī script. The presence of additional symbols for multiples of ten ranging from 20 to 90 seems to be a feature of Aryan languages. We noticed the presence of signs, viz. in the Indus text that consist of Prakrit-like medial-vowel signs, namely and .

Indus weights

The weights excavated from Harappan settlements conform to two standards (Figure 3). For larger weights, the decimal system was used and for smaller weights the binary system was followed. The smallest weight in the binary series is 0.856 g (ref. 16) and the largest is 13.7 g. They tend to bear the ratio 1 : 16.

Integers, fractions and operators

The larger weight unit is approximately 1370 g. A weight measure closer to this value, namely 1400 g was in vogue in India up to 1957, when the metric system was adopted. This measure was termed as 'vīśai' in Tamil since ages. The Tamils also handled fractions in hexadecimal units such as vīśam (1/16) paḍi, araikkāl (1/8) paḍi, kāl (1/4) paḍi, arai (1/2) paḍi, mukkāl (3/4) paḍi, etc. in their daily chores as volumetric measure. The fractions ranging from 1/16 to 15/16 are expressed in words in the following way in Tamil.

vīśam, araikkāl, mūnṟu vīśam, kāl, kāl(ē) vīśam,
kāl(ē) araikkāl, kāl(ē) mūnṟu vīśam, arai,
arai(ē) vīśam, arai(ē) araikkāl, arai(ē) mūnṟu vīśam,
mukkāl, mukkāl(ē) vīśam, mukkāl(ē) araikkāl,
mukkāl(ē) mūnṟu vīśam

These words can also be expressed in mathematical notation as follow:

1/16, 1/8, 3/16, 1/4,
1/4+1/16, 1/4+1/8, 1/4+3/16, 1/2,
1/2+1/16, 1/2+1/8, 1/2+3/16, 3/4,
3/4+1/16, 3/4+1/8, 3/4+3/16.

The basic fractional units needed to express these 15 hexadecimal fractions are only six. They can be grouped into two triads of the quarternary and hexadecimal base: {1/4, 1/2, 3/4} and (1/16, 1/8, 3/16). Special symbols for these triads are found in *Kanakkathikāram* (ref. 17), a

Figure 3. Indus weights.

mathematical treatise in Tamil authored by Kārināyanār. They are {வழ, ஆ}, {ஊ, ஹ, ஈ}. Two triads of this kind indicating the fractional units were found in the Indus text. They are {𑋪, 𑋫, 𑋬}; {𑋭, 𑋮, 𑋯}. The first triad values were obtained from Harappan seals and the second triad values from Mohenjodaro. The textual context with which the first triad appears indicates that it belonged to quarternary base. This is evident from the trigrams associated with it, viz. {𑋪𑋫𑋪, 𑋪𑋫𑋪, 𑋪𑋫𑋪}, and they indicate the values {kāl(ē), arai(ē), muk-kāl(ē)} or {1/4+, 2/4+, 3/4+}. Here the sign 𑋪 stands for the number 4. The medial vowel /ē/ acts as the 'addition' operator in Tamil. A reference to this nature is found in verse 164 of *Tolkāppiyam*[14]:

> All words of vowel- or consonant-ending
> Denoting measure of capacity, weight and number
> Will have the appropriate empty morpheme /ē/ for
> Where they are followed by terms
> Denoting lesser units of measure, weight and number,
> Thus has the authority decreed.

The members of the triad {𑋪, 𑋫, 𑋬} denote the values {1/, 2/, 3/} respectively. We have also drawn inference that the 'crab' symbol 𑋰 embedded in the second triad indicates the hexadecimal base. Here the sign 𑋰 stands for the number 16. We were tempted to assign the phonemic value 'ṇ' to the Indus sign 𑋰 so as to conform its position as 16th row in the periodic table of phonemes (akṣara mālā). The initial vowels are listed in the first row and the vowel-consonants starting from 'k' to 'h' appear in subsequent rows. The triad {𑋭, 𑋮, 𑋯} indicates the values {vīśam, araikkāl, mūnṟu vīśam} or {1/16, 2/16, 3/16}. The members of this triad appear in isolation and do not accompany the operator /ē/, indicating that they denote a lesser unit. The fractional value 1/8 if split as $1/2 \times 1/4$ would sound like arai-k-kāl in Tamil. Here the consonant 'k' acts as the 'multiplication' operator.

The Tamils classified numbers (eṇkaḷ) into two categories. They are integers (pērilakkam) and fractions (ciṟṟilakkam). They further subdivided the fractional numbers into two categories, namely the higher denomination fraction values (mēlvāyc ciṟṟilakkam) and the lower denomination fraction values (kīḻvāyc ciṟṟilakkam). The operator /ē/ (ஏ) involved in denoting fractional values is termed as 'cāriyai' in Tamil. The fractions whose values lie between 1/320 (வந) and unity (க) are termed as higher denomination and the rest as lower denomination. The hexadecimal fractions fall under the class of higher denomination. An indication of this kind is depicted by upward arrow in the Indus triads identified for fractions. Also, situations arise to denote the value for mixed fractions, such as six and a quarter (6 + 1/4), seven and three-quarter (7 + 3/4), etc. Evidence for such usage is found in the Indus text. The following bigrams 𑋪𑋪𑋪, 𑋪𑋪𑋪, 𑋪𑋪𑋪, 𑋪𑋪𑋪 that appear in the Indus text stand for the values aint(ē), āṟ(ē), ēḻ(ē), oṉpat(ē) or 5+, 6+, 7+, 9+. These numbers with the attendant operators if followed by a fraction would indicate the values for mixed fractions. We associate the conflated Indus sign 𑋲 to represent the number 900+ (nine hundred and). It is composed of three elements, namely 𑋪, 𑋪, 𑋰, and stands for the product $3 \times 10 \times 10 \times 3+$. The ordinal number 1000th (one thousandth) appears as the bigram 𑋪𑋱 in the Indus text. We read the sign 𑋪 to be the Tamil conjunct-vowel 'ttu' (த்து) and the ordinal number 1000th is spelt as āyirattu (ஆயிர-த்து) in Tamil.

Discerning the value for the Indus sign 𑋬

We contemplated that the Indus sign 𑋬 must be a fraction based on the clue obtained from the textual context. The two bigrams consisting of the sign 𑋬 appear as 𑋰𑋬 and 𑋗𑋬 in the Indus text. Assigning a value 9/10 to the sign 𑋬 yields the value 90 to the bigram 𑋰𑋬 and 900 to the bigram 𑋗𑋬. These numbers could possibly be expressed in words as 'nine-tenth of hundred' and 'nine-tenth of thousand'. Also they could be spelt as toḻ-nūṟu and toḻ-āyiram if translated into Tamil. The prefix toḻ takes the noun form tōḷ in Tamil and is the name for human shoulder. The fractions 1/4 and 1/2 are named 'kāl' and 'arai' in Tamil. These also mean 'leg' and 'waist' respectively. Likewise, the fraction 9/10 might have been spelt as the body part 'tōḷ' in archaic Tamil. A reference to shoulder being used as the unit of measure comes from the Tamil proverb that translates into English as, 'Respect thy ward, A companion if he scales above thy shoulder'. Also the Tamil proverb that reads as 'To the eight-span body, head is vital' helps to infer the shoulder level to be the height of the body sans the head. If the head is presumed to be a span in length, then the shoulder level approximates to the value 7/8 or the fraction 9/10. This explanation, if accepted by the scholars, would throw more light into the genesis of Dravidian languages and Tamil, in particular. With the same token, the bigram 𑋰𑋬 should indicate the number 9 which stands for the product $9/10 \times 10$. It should be spelt as 'toḻ-pattu' or 'tom-pattu'. A similar coinage of the term 'tom-midhi' appears in Telugu and its articulations much simplified by dropping the leading consonant 't' and the word becomes 'om-patu' and 'om-battu' in Tamil and Kannada respectively. There is a likelihood that the bigram 𑋰𑋬 could appear in artifacts to be excavated.

Arithmetic and astrology

The Indians have also classified the faculty of arts into 64 kinds and among them 'orthography' ranks first followed by the 'writing skill'. 'Arithmetic' and 'astrology' rank in 3rd and 8th respectively. The poetess Avvaiyār values orthography and arithmetic skills in equal terms to be

worth the eyes of human beings. We believe that the Indus people might have used arithmetic involving circular measures as well. A large number of private and public wells that were circular in cross-section have been unearthed from many of the Indus settlements. Notable among them is a well found at Lothal situated 270 km from Mohenjodaro. It is 7.9 ft in diameter and 22 ft deep, and built of kiln-fired radial bricks. We presume that the Indus people might have been acquainted with the existence of a constant proportion between the diameter and circumference of a circle and assigned a value approximate to 22/7 to it. This mixed fraction 3 + 1/7, if expressed in Harappan notation, would appear as 𐣻𐣼𐣽. Had the Harappans used this approximation to 'pi', it may figure in the artifacts to be examined.

We could identify some Indus signs that would perhaps stand for the zodiac symbols in addition to their role as literal characters. A need to invent signs for zodiac symbols would have arisen when the Indus folk needed to cast horoscopes for individuals. References to such practices abound in the epics *Ramayana* and *Mahabharata*. The likely symbols one encounters in the Indus text that resemble the zodiac symbols and signs for Aries to Pisces are the following:

Zodiac symbol						
Indus symbol						
Zodiac symbol						
Indus symbol						
Zodiac sign						
Indus sign						
Zodiac sign						
Indus sign						

Roman numeral	I	II	III	IV	V	VI
Indus numeral	𐣻	𐣻𐣻	𐣻𐣻𐣻	𐣻𐣻𐣻𐣻	𐣽	𐣽𐣻
Roman numeral	VII	VIII	IX	X	L, C	D, M
Indus numeral	𐣽𐣻𐣻	𐣽𐣻𐣻𐣻	𐣽𐣻𐣻𐣻𐣻	𐣼	𐣾,𐣿	𐣾,𐣼

There is remarkable semblance between the European zodiac symbols and the Indus signs. Also, it seems that the Roman numerals could have originated from the Indus Civilization. We configured the necklace-wearing human being 𐣿 to represent 'the maiden' or the Virgo symbol, and the human holding the bow in his hand to stand for the Sagittarius symbol. A reference to pictograms involving flora and fauna is found in two successive verses, viz. 278 and 279 in *Tolkāppiyam*. We identified the pictographic sign 𐣰 to stand for the animal figure 'bull', and assigned the phonemic value 'cē' to it. Two alternate signs for the 'bull' appear as 𐣰, 𐣱 in the Indus text. Verse 279 of *Tolkāppiyam*[14] substantiates this view by the following description that translates as:

> Where cē denotes pe̱ṟram [bull]
> It needs the complementary morpheme i̱ṉ.

Likewise, we identified the pictographic sign 𐣷 to stand for the plant figure 'tree' and assigned the phonemic value 'cē' to it. Two alternate signs for the 'tree' appear as 𐣸, 𐣷 in the Indus text. Verse 278 of *Tolkāppiyam*[14] substantiates this view by the following description that translates as:

> The tree-name cē
> Is subjected to the same change
> As that in the case of the tree-name oṭu
> [Augmentation of soft consonant].

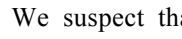
The presence of the bigrams 𐣵𐣷 and 𐣶𐣰 involving the soft consonant(ṅ) 𐣵 and the absence of the bigrams 𐣽𐣷 and 𐣽𐣰 involving the medial vowel (ē) do indicate that the signs 𐣷 and 𐣰 are pictograms and stand for the same phoneme, viz. 'cē'. The verse 129 of the grammatical treatise *Naṉṉūl*[18] lists 42 one-letter words that are candidates for pictograms. These are: ā, ī, ū, ē, ai, ō, mā, mī, mū, mē, mai, mō, tā, tī, tū, tē, tai, pā, pū, pē, pai, pō, nā, nī, nē, nai, nō, kā, kū, kai, kō, vā, vī, vai, vau, cā, cī, cē, cō, yā, no, tu. The letter 'cē' denoting the pictograms for tree and bull figures in this list. Verses 43 and 44 of *Tolkāppiyam*[14] corroborate this point in more generic terms:

> The seven long vowels
> Do abide as one-letter words. (verse 43 of 1602)
> None among the five short vowels
> Is a sense entity in itself. (verse 44 of 1602)

Many of these one-letter words appearing in *Naṉṉūl* are homophones and they stand for words with the following meanings: cow; fly, bee, gnat; meat, flesh, food; arrow; beauty, lord, master; alas, shutter; big, great, flour, mango, beast, he-elephant; high, height, shy; three, old age, get old; desire, excellence; black, darkness, ink; to smell, to take; to give, strength; fire, wicked, knowledge; purity, hostility; deity, acquiring; sew, pierce, stitch; poem, cotton thread; flower, blossom, beauty; froth, foam, fear, cloud; bag, purse, greenness, hood of a cobra; go, leave, proceed; tongue, word; you, thou; love, mercy; crush, defame, destroy, burn; to suffer; park, scales, protection; screeching, outcry; hand, arm; king, father, cow; come, leaping, galloping; die, disappear, flower; put, lay, abuse, curse; to seize, to snatch; death, to be tired; pus, disgust; bull, red; fortress; what, which; suffering, disease; to eat.

About 150 bull symbols figure in the Indus seals above which the Indus text appears. The attributes of the bull differ slightly. Many are humped bulls, a lot have short horns and a few have two long horns. The Indus folk might have coined different names for these figures. In Tamil too, many names are associated with the fauna 'bull'. Besides the word 'cē', the other names for bull are 'eruthu', 'ēṟu', 'kāḷai', 'peṟṟam' and 'māṭu'. The word 'māṭu' also signifies wealth in Tamil. About 38% of the Indus text ends with the signs  and . They stand for the medial-vowel signs e and ē respectively. The two signs  , denoting the one-letter word 'cē' also appear at the terminal position in the Indus text. The presence of bigrams , in the Indus text indicate that the sign can be construed as the allograph for the sign .

Dance and music

The appearance of a 'dancing figurine' obtained from Mohenjodaro suggests that dance programmes might have been conducted with the accompaniment of music in those days. Also, it is a known fact that the music of ancient India was based on seven musical sounds called *svara*. A reference to the seven musical notes appears in *Amar-Kosha*[19], a treatise written by Amar Singh, the celebrated Buddist compiler. The Indus folk may have employed the seven basic notes, namely sa (C), re (D), ga (E), ma (F), pa (G), dha (A), ni (B) while rendering music. These musical notes if expressed in Indus notation would appear as:  . We suspect that the exposure to these musical note signs would have led to the intrusion of the note signs and into the early Tamil–Brahmi writings. Mahadevan[15] assigns the phonemic value 's' and 'dh' to the two non-Tamil characters found in the Tamil–Brahmi inscriptions. We associate those Tamil–Brahmi characters and to the Indus signs and respectively. The presence of conflated signs such as , in the Indus text could be construed to represent the occurrence of two musical notes in succession. Suryanarayana Sastri[20] elucidated the ulterior presence of nine additional phonemes, viz. g, j, ḍ, d, b, ṛ, h, ś, bh present in written Tamil. The assimilation of non-Tamil words also finds place in *Tolkāppiyam*[14] (verse 884). A reference to signify the seven notes of the diatonic scale using the seven long vowels of the Tamil alphabet appears in *Divākara nighaṇḍu* (1300 ybp)[21]. The Tamil musical treatise *Panchamarabu*[22] (1000 ybp) describes the development of septatonic scale and the assignment of the seven basic notes in 12 houses that correspond to the 12 signs of the zodiac.

Some important observations

1. The signs  , do not occur within the same seal. Likewise, the signs , do not occur within the same seal. So also, the signs , do not occur within the same seal. They are scribe-specific and represent the same phoneme.
2. Like the presence of bigram , the bigram could also occur.
3. Like the presence of bigram , the bigram could also occur.
4. The signs , do not occur within the same seal. They have the same phonetic value: 'cē'.
5. The bigrams , do not occur as the signs , embed the medial vowel sign ē.
6. The bigrams , , , stand for the ordinal numbers 5+, 6+, 7+, 9+.
7. The signs , , indicative of fractional measure do not occur in isolation. They precede with the numerical sign , .
8. The signs , , indicative of fractional measure can also appear as , , .
9. The number 9 could be depicted by the bigrams , .

Conclusion

The two frequently used signs in the Indus script, namely the jar symbol and the short double vertical strokes symbol are identified to be equivalent to the medial-vowel signs ി and ു of the Tamil script. The other two often used signs, namely the comb symbol and the arrow symbol are identified to be the medial-vowel signs ೆ and ೨ of the Kannada script. Likewise, the mortar with and without the pestle symbols and are identified to be the initial-vowel signs അ and ഉ of the Devanagari script. Besides that, the six predominantly used fish-like signs namely , , , , , that appear in the Indus text bear semblance to the Kannada language characters ವ, ಪ, ಮ, ಬ, ಷ, ಘ and correspond to the phonemes va, pa, ma, ba, ṣa, gha. We have anticipated signs for two more fish-like symbols corresponding to the missing labial phonemes 'pha' (ಫ) and 'bha' (ಭ). They should bear semblance with the fish signs and , taking cue from the Kannada script. They were found in the BW corpus (2004) on the Indus text and appear as and . All these eight fish-like signs share a common feature that they tend to pair with the medial-vowel sign to the left. The trident symbol that follows 3–8 short vertical stroke signs in the Indus text is identified to be the semi vowel 'y' or the consonant ய of Tamil. The medial-vowel signs in Kannada that follow the consonants always appear along the direction of the writing. This feature is also observed in the Indus text. All the Tamil and Kannada medial-vowel signs have been identified in the Indus text and plausible phonemic values assigned to select the Indus signs and words. The occurrence of both short and long medial-vowel signs for 'e' and 'o' in the Indus text unequivocally indicates that the language underlying the Indus writing belongs to the Dravidian language family.

A number system akin to that followed by ancient Tamils was in vogue during the Harappan epoch.

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