

Archaic cuneiform numbers

Robin Leroy, Anshuman Pandey, and Steve Tinney

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1 Summary

This document proposes encoding some numerals used in the Uruk and Early Dynastic periods in conjunction with the Sumero-Akkadian cuneiform script¹ and the proto-cuneiform script². The proposed characters are listed in section 2.

The non-numeric signs of proto-cuneiform will be the subject of a separate proposal; we need only note here that the divergence between the approaches to character identity in modern scholarship requires that proto-cuneiform be disunified from cuneiform: proto-cuneiform is effectively treated as an undeciphered script. In contrast, the cuneiform encoding model is semantic, requiring an understanding of the text to correctly encode it.

However, the *numerals* used in proto-cuneiform should be unified with ones used in the Early Dynastic period, for the reasons set forth in section 4. The proposed “curved”, or “curviform”, numerals³ should however *not* be unified with the already-encoded cuneiform numerals⁴. Since the encoding proposals for the cuneiform script twenty years ago provisionally considered the curviform numerals to be glyph variants of the cuneiform numerals, a detailed rationale is provided in section 3, including compatibility considerations in section 3.7.

The overall picture of unifications and disunifications over time is illustrated in table 1. The Script_Extensions property assignments in section 2.2 reflect the overlap.

[TODO(egg): Mention the other sections here too.]

	Uruk III & earlier	ED – Ur III	OB & later
Numerals	This proposal		
	Future Pcun		Existing Xsux
Non-numeric signs			

Table 1: Usage of existing, proposed, and future characters across functions and time periods.

¹ISO 15924: Xsux, Script property value long name: Cuneiform; encoded since Unicode Version 5.0.

²ISO 15924: Pcun, not yet encoded.

³ 𐎶 1-9(aš^c = N₁), 𐎷 1-5(u^c = N₁₄), 𐎸 1-9(ḫeš₂^c = N₃₄), 𐎹 1-5(ḫeš^cu^c = N₄₈), etc.

⁴ 𐎶 1-9(aš), 𐎷 1-5(u), 𐎸 1-9(ḫeš₂), 𐎹 1-5(ḫeš^cu), etc.

2 Proposed changes to the Standard

2.1 Summary of proposed characters

2.2 Properties

2.3 Character names list

2.4 Core specification text

3 Rationale for curviform–cuneiform disunification

TODO(egg): blurb.

3.1 The cuneiform encoding model


As outlined in, *e.g.*, [UTR56], the cuneiform encoding model is diachronic; each character may have wildly different glyphs depending on time period and region. For instance, the sign IM may resemble  in texts from Early Dynastic IIIa Suruppag as in the character code charts,  later in the third millennium⁵,  in Old Babylonian cursive,  in Neo-Assyrian, but is always encoded as U+1214E CUNEIFORM SIGN IM.

This encoding model allows for the interoperable representation of editions of diachronic reference works such as sign lists⁶ and dictionaries⁷, and of composite texts⁸. By being compatible with similarly diachronic transliteration practice (that is, by avoiding distinctions finer than those made in transliteration), the encoding model also allows for automated conversion of transliterated corpora to cuneiform, which has proven useful as a processing step in analyses such as [Rom24; JJ24]⁹. The diachronic approach is also useful for pedagogic applications¹⁰.

3.2 Arguments for curviform–cuneiform unification


In this context, the argument was made in [L2/04-099], as part of discussion of the cuneiform encoding¹¹ that the curviform numerals, which occasionally appear in the Ur III period and are used heavily in the Early Dynastic period, were a stylistic distinction unifiable with the cuneiform digits, and that an archaizing Ur III font or an Early Dynastic font could have curviform glyphs for the appropriate characters.

Some co-occurrence of curviform and cuneiform digits was known and acknowledged. [L2/04-099, p. 3] cites [NDE93, p. 62], which is a copy of [P020054], an Early Dynastic IIIb administrative tablet from Nirsu. The excerpt cited, lines 1–3 of column 1 of the obverse, is as follows:

⁵Merging with U+1224E  NI₂.



⁶Notably [VT+14] and the online edition of [Bor10] in [Jim+23, Signs].





















⁷Notably [TJV17] and the online edition of [Sch10] in [Jim+23, Dictionary].

⁸For example, there are Neo-Assyrian and Neo-Babylonian copies parts of the laws of , as well as Old Babylonian copies in both archaizing and cursive styles. Because of damage on the stele [P249253], some sections are known only from those copies. See [Oel22, pp. 110 sqq.].

⁹Attendees may recall the summary given on the third day of UTC #180, as recorded in [L2/24-159]. Other readers may refer to [Svā+24, pp. 242, 148].



¹⁰For instance, Old Babylonian grammar may be taught in the Neo-Assyrian script, as in [Cap02].

¹¹At that time scoped to the repertoire of the Ur III period and later; see [L2/03-162, p. 1], although many disunifications, such as  ≠ , were informed by Early Dynastic distinctions.

 ¹²						
1(NĖŠ ₂)	1(U)	1/2(DIŠ)	5(DIŠ <i>tenû</i>)	gi	us ₂	sa ₂
	7.5 (ropes)		5	reed	side	equal
 ¹³						
3(U)	6(DIŠ <i>tenû</i>)	gi	sa ₁	sa ₂		
3(ropes)	6	reed	front	equal		
						
ašag-bi	1(BUR ₃)	1(EŠE ₃)	1(IKU ^c)	1/2(IKU ^c)		
this field						
						
				tug _x (LAK483)-si-ga-kam ¹⁴		
				deep ploughing		



The argument made in [L2/04-099, p. 4] is that this is comparable to a stylistic distinction such as¹⁵


465 metres, equal lengths
198 metres, equal widths
this field: 9, 18 hectares, deeply ploughed




where the numerals have the same structure ([L2/04-099] contrasts this to the different structures of ASCII digits and roman numerals). That document further claims that “the number signs do not normally carry in their individual signs the meaning of what they are used to measure”, and that curviform and cuneiform numerals “are not normally mixed together in a single numerical expression”, noting the exceptions of [P232278; P232280]. In addition, [L2/04-099, p. 4] points out that the cuneiform numeric signs are descended from the curviform ones (this is undisputed), and claims there is only a small re-allocation of the function of signs (from  to  numerals). It therefore comes to the conclusion that the use of curviform numerals should be seen as a formatting distinction, rather than one that should be represented in plain text, and insists that the encoding should capture the lineal historical descent of those signs, presumably to take advantage of the benefits of diachronic encoding described in section 3.1.

Although they had been part of the preliminary proposal [L2/03-393R], the curviform numerals were therefore removed from [L2/04-036] and [L2/04-189], which both state that “The distinction between curved numerals and their cuneiform descendants is treated as glyphic for the purposes of the present proposal; this issue will need to be revisited in subsequent encoding phases.”

The time has come to revisit this issue. As we will see in section 3.3, numerals can only be interpreted in the context of what they measure *i.e.*, as part of a metrological system. In section 3.4 we will see that in some periods:

- the functions and use of the numerals vary beyond the mere / switch;

¹²As noted in [Pow87, p. 466], this sign has a very short “tail” in this period, so that it is wider than it is tall, and can at first seem like a large  in copies. The photos in CDLI clearly show that this is in fact a vertical wedge.

¹³Note that ED IIIb  numerals have a somewhat different appearance from those of the Ur III period used in this transcription; the sign  in [P020054] looks more like Ur III .

¹⁴Transliteration after [Lec20, p. 325].

¹⁵We have taken the liberty of adjusting the analogy to use measures approximately equal to those in [P020054], instead of a field of five by twenty-five metres.

- the contrast between curviform and cuneiform numerals is commonly used to distinguish metrological systems;
- some metrological systems commonly mix curviform and cuneiform in single numerical expressions.

3.3 A primer on classic Ur III and Old Babylonian metrologies

𒂗𒍪 𒂗𒍪𒂗𒍪𒂗𒍪 𒂗𒍪
 𒂗𒍪 𒂗𒍪𒂗𒍪𒂗𒍪𒂗𒍪 𒂗𒍪𒂗𒍪𒂗𒍪
 𒂗𒍪 𒂗𒍪𒂗𒍪𒂗𒍪𒂗𒍪𒂗𒍪𒂗𒍪𒂗𒍪

*I want to write tablets: the tablet of 1 gur
 of barley to 600 gur; the tablet of 1 shekel
 of silver to 10 minas [...]*

Edubba'a D

Before diving into the usage of the curviform numerals in the Early Dynastic period to explain the contrast with cuneiform numerals, it is useful to understand the usage of the already-encoded characters in the Ur III and Old Babylonian periods.

As is well known¹⁶ a sexagesimal place value system (SPVS) was used in Mesopotamia from the late third millennium onwards. One should bear in mind, however, that other systems were used; the SPVS was primarily used in calculations, with results being expressed in non-positional systems [Rob08, p. 76; Rob22]. The digits 1–59 of the SPVS have inner structure which is reflected in the encoding: the digits 1–9 are the individual characters 𒂗–𒂗𒍪, the multiples of ten (10–50) are 𒂗–𒂗𒍪, but the other digits 11–59 are sequences 𒂗–𒂗𒍪𒂗𒍪; in effect the base-sixty digits are themselves written in base ten, with a different set of symbols for the tens place. This reflects the origin of the sexagesimal place value system; it derives from a *non-positional* system, hereafter the *cuneiform discrete counting system* $S_{\text{Ur III/OB}}$, which had different signs for the units 𒂗–𒂗𒍪, tens 𒂗–𒂗𒍪, sixties 𒂗–𒂗𒍪 (with larger wedges than the units), six hundreds 𒂗–𒂗𒍪, three thousand six hundreds 𒂗–𒂗𒍪, and thirty-six thousands 𒂗–𒂗𒍪.

3.3.1 The discrete counting system

The relations between the values of the signs in the cuneiform discrete counting system may be summarized by the following factor diagram¹⁷, where the number over arrow indicates the multiple of the preceding sign (right of the arrow) corresponding to the following sign (left).

$$\diamond \xleftarrow{10} \diamond \xleftarrow{6} \text{𒂗} \xleftarrow{10} \text{𒂗} \xleftarrow{6} \text{𒂗} \xleftarrow{10} \text{𒂗} \quad (S_{\text{Ur III/OB}})$$

For example, the number $1729 = ((2 \times 10 + 8) \times 6 + 4) \times 10 + 9 = 28 \times 60 + 49$ would be written 𒂗𒂗𒂗𒂗𒂗𒂗 in the discrete counting system, and 𒂗𒂗𒂗𒂗 in the sexagesimal place value system.






¹⁶See, e.g., [Uni16, §22.3.3, sub “Cuneiform Numerals”].









¹⁷These diagrams, which have become standard in discussions of Mesopotamian metrology, originate with [Fri78, p. 10], where they are called *step-diagrams*.

This intertwining of units and numerals explains the large number of already-encoded numeral series:

- \mathbb{I} - \mathbb{W} used in $S_{\text{Ur III/OB}}$ and the SPVS as well as with overt units;
- \mathbb{L} - \mathbb{M} used in $G_{\text{Ur III/OB}}$, of which \mathbb{L} - \mathbb{M} are also used in $S_{\text{Ur III/OB}}$ and the SPVS as well as with overt units;
- \mathbb{N} - \mathbb{O} used in $S_{\text{Ur III/OB}}$, and sometimes with overt units;
- \mathbb{P} - \mathbb{Q} used in $S_{\text{Ur III/OB}}$;
- \mathbb{R} - \mathbb{T} used in $S_{\text{Ur III/OB}}$ and $G_{\text{Ur III/OB}}$;
- \mathbb{U} - \mathbb{V} used in $S_{\text{Ur III/OB}}$ and $G_{\text{Ur III/OB}}$;
- \mathbb{W} - \mathbb{X} used in $C_{\text{Ur III/OB}}$ as well as with overt units of the weight system;
- \mathbb{Y} , \mathbb{Z} , \mathbb{A} , \mathbb{B} , \mathbb{C} used in $C_{\text{Ur III/OB}}$;
- \mathbb{D} , \mathbb{E} , \mathbb{F} , \mathbb{G} used in $C_{\text{Ur III/OB}}$ —note the overlap with \mathbb{I} - \mathbb{W} ;
- \mathbb{H} and \mathbb{I} used in $G_{\text{Ur III/OB}}$.

3.3.4 The length system

 60 ←  10 ←  12 ←  30 ←  (L_{Ur III/Ob})
 danna
berum
league
10.8 km
 US²⁵
cable
360 m
 nindan
nindanum
rod
6 m
 kuš₃
ammatum
cubit
50 cm
 šu-si
ubānum
finger
17 mm



 \leftarrow 30
 
 \leftarrow 6
 
 \leftarrow 10
 
 \leftarrow 2
 
 \leftarrow 6
 
 \leftarrow 30
 
 ($\bar{l}_{\text{Ur III/OB}}$)

eše₂
 ašlum
 rope
 60 m

gi
 qānum
 reed
 3 m

²⁵TODO

In addition, there are Akkadian names for the half-rope and half-reed, see [Pow87, pp. 463 sq.].

3.3.5 Fractions

TODO

3.4 Curviform numerals in early metrologies

At first sight, the metrological systems from the Early Dynastic period match the ones previously mentioned. In particular, the discrete counting system used in the Early Dynastic period (and earlier in the Uruk period) clearly mirrors system $S_{Ur III/Ob}$ [Fri07, p. 374; DE87, pp. 127, 165]:

$$\odot \xleftarrow{10} \bullet \xleftarrow{6} \text{D} \xleftarrow{10} \text{D} \xleftarrow{6} \bullet \xleftarrow{10} \text{D}, \quad (S)$$

Likewise the area system used in the Early Dynastic IIIb period mirrors system $G_{Ur III/Ob}$ [Dei22, p. 72; NDE93, p. 63; Fri07, p. 378; Gom16]:

$$\odot \xleftarrow{10} \bullet \xleftarrow{6} \star \xleftarrow{10} \bullet \xleftarrow{3} \text{D} \xleftarrow{6} \text{D}, \quad (G_{ED IIIb})$$

As noted in [L2/04-099, p. 4] (see section 3.2), the vertical \uparrow from $S_{Ur III/Ob}$ becomes a horizontal D in system S . It is however far from the only case of such a reallocation of function. The earlier form of System G was [DE87, pp. 141, 165; Fri07, p. 378]:

$$\bullet \xleftarrow{6} \odot \xleftarrow{10} \bullet \xleftarrow{3} \text{D} \xleftarrow{6} \text{D}, \quad (G)$$

Observe that, as noted in [DE87, p. 142], \odot changes meaning from $10\bullet$ in system G to $10\star$ in system $G_{ED IIIb}$. System G is used in the Uruk period, but also in the ED I–II period (it is the “area 2” system in [Cha03], whereas $G_{ED IIIb}$ is the “area 1” system).

3.4.1 Field lengths in Nirsu



The length system Early Dynastic IIIb of the state of Lagaš is of particular interest. As described in [Pow87, p. 466; Lec20, pp. 289 sq.], lengths are expressed in rods, but the unit sign D is generally omitted; in addition, only tens of rods are used; these are equal to one rope, but the sign D is not written either. Length shorter than one rope are expressed in half-rope using the $1/2$ sign D (again with no D), and then in reeds, *with* the sign D . Effectively, this yields the following factor diagram:

$$\begin{array}{c} \uparrow \xleftarrow{6} \text{D} \xleftarrow{2} \text{D} \xleftarrow{10} \text{D} \text{ } \text{D}^{28} \\ \begin{array}{l} 1 \text{ eše}_2 = 10 \text{ nindan} \\ 1 \text{ rope} = 10 \text{ rods} \\ 60 \text{ m} \end{array} \qquad \begin{array}{l} \text{gl} \\ \text{reed} \\ 3 \text{ m} \end{array} \end{array} \quad (L_{ED IIIb})$$

This is the system that was used to express the sides of the field in [P020054] discussed in section 3.2. In that tablet and others from the same period, such as the ones discussed in [Lec20], areas are expressed in system $G_{ED IIIb}$, with curviform numerals²⁹; in the absence of overt units, such as when dealing with length that



























²⁸Note that the reeds are counted using *tenû* numerals, D , D , D , etc.

²⁹TODO(egg): Note the handful of late Urukagina tablets that start to have cuneiform areas.






are integer multiples of a half-rope³⁰, the use of curviform or cuneiform numerals therefore disambiguates a numeric expression between an area and a length, and therefore the interpretation of its numerals between systems $G_{ED IIIb}$ and $L_{ED IIIb}$. The sign , which would also disambiguate the interpretation as an area, is sometimes used after areas in ED IIIb Lagaš, but not systematically; in particular the area of the first field in [P020054] does not use this suffix. See [Lec20] for many examples with and without .

3.4.2 Dyke lengths in Nirsu

[Pow87, p. 466] notes that reeds “are regularly written with the normal, cuneiform end of the stylus. Higher units are usually written with the reversed (round) end of the stylus.” [TODO(egg): also mention Krebern timer 1998 p. 303 with note 686.] Powell does not elaborate on the specifics of this mixed use of numerals, but a cursory search in CDLI finds many occurrences³¹, such as:







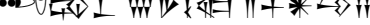


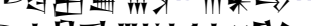



- [P221305, obv. 1, 4]³²                          

The system of grain³⁶ capacities in Ebla uses the following units³⁷:

 $\xleftarrow{2}$  $\xleftarrow{\frac{5}{2}}$  $\xleftarrow{4}$  $\xleftarrow{6}$ 

gu₂-bar ba-ri₂-zu nin₄ nin₂-sagšu an-zam_x

The 𐤀𐤁 and 𐤁𐤁𐤁 are generally counted using curviform numerals, and the smaller units using cuneiform \uparrow numerals. Indeed, a search on [Mil+07] for co-occurrences of 𐤀𐤁 with either of 𐤀𐤁 or 𐤁𐤁𐤁 finds the following expressions³⁸:

1. [P240532, *verso* 4, 9] 
2. [P240548, *verso* 1, 1] 
3. [P240655, *recto* 7, 9] 
4. [P240579, *verso* 4, 3] 
5. [P240675, *verso* 2, 2] 
6. [P240609, *verso* 3, 1] 
7. [P240533, *recto* 3, 3] 
8. [P240697, *recto* 1, 5] 
9. [P240653, *recto* 6, 2] 
10. [P240654, *recto* 2, 6] 
11. [P240531, *recto* 1, 8] 
12. [P241708, *recto* 1, 1] 
13. [P241904, *recto* 1, 1] 

[illegible]

³⁶Liquid capacities use a different system [Arc15, p. 229 with note 12]:

 $\xleftarrow{30}$



 $\xleftarrow{6}$

At a glance it seems that ∇ are counted with cuneiform numerals and higher units with curviform ones, thus

[illegible]

but we have not investigated this thoroughly.

³⁷TODO mention the other one citing Chambon and the footnote in Archi

³⁸We cite here only one attestation per tablet; most tablets contain several expressions mixing cuneiform  and larger with cuneiform  and smaller. In all cases the transcriptions given here are based on the EbDA transliterations, but the shape and orientation of the numerals was checked³⁹ on a photograph (from EbDA unless noted otherwise).

³⁹As we will see in Section 3.7.2, CDLI transliterations indicate numeral shape; however, as of this writing, they do so incorrectly on the Ebla corpus, claiming that all numerals are curviform, so we were not able to rely on them in this specific case.

⁴⁰ba-ri₂-zu₂, a variant spelling.

⁴¹Short for $\Box \Diamond \perp$.

⁴²Note the omitted $\square \Diamond \perp$.

⁴³Instead of the expected $\mathbb{P} \times \mathbb{P} \times \mathbb{P}$.

⁴⁴ not legible on the EbDA photo.

⁴⁵From CDLI photo.

⁴⁶From photo in [Arc89, p. 6].

⁴⁷Laid out as $\begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \end{bmatrix}$; on stacking patterns see Section 6.2.

formed by only two signs \Uparrow and \lhd , repeated as many times as necessary; this type of notation is highly standardized. Second, the order of magnitude of the numbers noted in this system is not indicated: $1, 6, 6^2, 6^3, 1/6, 1/6^2$, etc. are written in the same way, with the vertical wedge \Uparrow . The third feature concerns the exact function of

Figure 4: TODO [Cha12, p. 58]

one step. The scribes of the Early Dynastic Period (c. 2600 BC), for instance, represented the number 648,000 with: but never with the repetition .

Figure 5: TODO [Cha12, p. 59]⁵⁰

repetition of the same sign refers to both the capacity unit signified—often but not necessarily written immediately afterwards—and its value. The units of measurement are written in descending order from left to right—just as we would write 3 km, 120 m, 50 cm. For example:

☞☞☞ še bar ☞ *ba-rí-zu*

'3 *gubar* (capacity units) and 1 *parīsu*'.

Figure 6: TODO [Cha12, p. 61]











This is particularly true of the signs , ,  and , whose form explicitly denotes the fractions 1/6, 2/6, 3/6, and 4/6 of the barig capacity measure written  in Mesopotamia—also transcribed by Assyriologists as 1 bān, 2 bān, 3 bān, and 4 bān with reference to the bān measure worth 1/6 of the barig. At Ebla, the sign  is most often associated with the *parisu* measure, while the signs , ,  and  refer to 1, 2, 3,

Figure 7: TODO [Cha12, p. 64]


shape. The principle of notation is additive: each sign is noted as many times as necessary (e.g.,  transliterated as 2(šar₂) 1(geš'u) 3(u), means $2 \times 3600 + 1 \times 600 + 3 \times 10$). The system is based on an alternation of factors ten and

Figure 8: TODO

might think of one fabric and a half,¹¹ but the presence of notations with “2D 2U”, “3D 3U”, and “6D 6U” (Fig. 1) elements excludes that one deals with fractions, as these notations are not consistent with those of Šuruppag’s weight measurement system.¹² The notation “1D gada” in o. ii 1 and r. vi 1, along with the total of “39



Fig. 1. Combinations of numerals attested in Š. 742.

Figure 9: Discussion of the contrast between \triangleright and \triangleright numerals in [Gor23, p. 162].

as, for example, in TM.75.G.3125 = ARET III 107 o. iv 1, “4⁹ ¹⁰ ¹¹ ¹² ¹³ ¹⁴ ¹⁵ ¹⁶ ¹⁷ ¹⁸ ¹⁹ ²⁰ ²¹ ²² ²³ ²⁴ ²⁵ ²⁶ ²⁷ ²⁸ ²⁹ ³⁰ ³¹ ³² ³³ ³⁴ ³⁵ ³⁶ ³⁷ ³⁸ ³⁹ ⁴⁰ ⁴¹ ⁴² ⁴³ ⁴⁴ ⁴⁵ ⁴⁶ ⁴⁷ ⁴⁸ ⁴⁹ ⁵⁰ ⁵¹ ⁵² ⁵³ ⁵⁴ ⁵⁵ ⁵⁶ ⁵⁷ ⁵⁸ ⁵⁹ ⁶⁰ ⁶¹ ⁶² ⁶³ ⁶⁴ ⁶⁵ ⁶⁶ ⁶⁷ ⁶⁸ ⁶⁹ ⁷⁰ ⁷¹ ⁷² ⁷³ ⁷⁴ ⁷⁵ ⁷⁶ ⁷⁷ ⁷⁸ ⁷⁹ ⁸⁰ ⁸¹ ⁸² ⁸³ ⁸⁴ ⁸⁵ ⁸⁶ ⁸⁷ ⁸⁸ ⁸⁹ ⁹⁰ ⁹¹ ⁹² ⁹³ ⁹⁴ ⁹⁵ ⁹⁶ ⁹⁷ ⁹⁸ ⁹⁹ ¹⁰⁰ ¹⁰¹ ¹⁰² ¹⁰³ ¹⁰⁴ ¹⁰⁵ ¹⁰⁶ ¹⁰⁷ ¹⁰⁸ ¹⁰⁹ ¹¹⁰ ¹¹¹ ¹¹² ¹¹³ ¹¹⁴ ¹¹⁵ ¹¹⁶ ¹¹⁷ ¹¹⁸ ¹¹⁹ ¹²⁰ ¹²¹ ¹²² ¹²³ ¹²⁴ ¹²⁵ ¹²⁶ ¹²⁷ ¹²⁸ ¹²⁹ ¹³⁰ ¹³¹ ¹³² ¹³³ ¹³⁴ ¹³⁵ ¹³⁶ ¹³⁷ ¹³⁸ ¹³⁹ ¹⁴⁰ ¹⁴¹ ¹⁴² ¹⁴³ ¹⁴⁴ ¹⁴⁵ ¹⁴⁶ ¹⁴⁷ ¹⁴⁸ ¹⁴⁹ ¹⁵⁰ ¹⁵¹ ¹⁵² ¹⁵³ ¹⁵⁴ ¹⁵⁵ ¹⁵⁶ ¹⁵⁷ ¹⁵⁸ ¹⁵⁹ ¹⁶⁰ ¹⁶¹ ¹⁶² ¹⁶³ ¹⁶⁴ ¹⁶⁵ ¹⁶⁶ ¹⁶⁷ ¹⁶⁸ ¹⁶⁹ ¹⁷⁰ ¹⁷¹ ¹⁷² ¹⁷³ ¹⁷⁴ ¹⁷⁵ ¹⁷⁶ ¹⁷⁷ ¹⁷⁸ ¹⁷⁹ ¹⁸⁰ ¹⁸¹ ¹⁸² ¹⁸³ ¹⁸⁴ ¹⁸⁵ ¹⁸⁶ ¹⁸⁷ ¹⁸⁸ ¹⁸⁹ ¹⁹⁰ ¹⁹¹ ¹⁹² ¹⁹³ ¹⁹⁴ ¹⁹⁵ ¹⁹⁶ ¹⁹⁷ ¹⁹⁸ ¹⁹⁹ ²⁰⁰ ²⁰¹ ²⁰² ²⁰³ ²⁰⁴ ²⁰⁵ ²⁰⁶ ²⁰⁷ ²⁰⁸ ²⁰⁹ ²¹⁰ ²¹¹ ²¹² ²¹³ ²¹⁴ ²¹⁵ ²¹⁶ ²¹⁷ ²¹⁸ ²¹⁹ ²²⁰ ²²¹ ²²² ²²³ ²²⁴ ²²⁵ ²²⁶ ²²⁷ ²²⁸ ²²⁹ ²³⁰ ²³¹ ²³² ²³³ ²³⁴ ²³⁵ ²³⁶ ²³⁷ ²³⁸ ²³⁹ ²⁴⁰ ²⁴¹ ²⁴² ²⁴³ ²⁴⁴ ²⁴⁵ ²⁴⁶ ²⁴⁷ ²⁴⁸ ²⁴⁹ ²⁵⁰ ²⁵¹ ²⁵² ²⁵³ ²⁵⁴ ²⁵⁵ ²⁵⁶ ²⁵⁷ ²⁵⁸ ²⁵⁹ ²⁶⁰ ²⁶¹ ²⁶² ²⁶³ ²⁶⁴ ²⁶⁵ ²⁶⁶ 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ness to Early Dynastic Food, which starts with \mathbf{D} numerals.

This is a clear contrast between $\mathbf{—}$ and \mathbf{D} in this period, and genuine ambiguity can arise if it is lost; for instance, the personal name $\mathbf{—}\mathbf{A}$ occurs on its own line in the aforementioned administrative texts; a line $\mathbf{D}\mathbf{A}$ would instead be read as “one slave”.

3.6 Limited benefits of diachronic encoding for numerals

The argument in favour of diachronic encoding is that it facilitates interoperability in a variety of use cases, as we have outlined in section 3.1. While these benefits are real and now visible for cuneiform signs, similar considerations are not generally applicable to curviform numerals.

Diachronic reference works such as sign lists and dictionaries tend to not include numbers, or when they do, they treat them separately, and include signs such as $\mathbf{—}$ that have both numeric and non-numeric values in both the main list and the section on numbers. For instance, [Sch35, pp. 123 sqq.] lists all of $\mathbf{—}\mathbf{—}\mathbf{—}\mathbf{—}\mathbf{—}$ together with $\mathbf{D}\mathbf{—}\mathbf{—}\mathbf{—}\mathbf{—}\mathbf{—}$, while $\mathbf{—}$, $\mathbf{↗}$, and $\mathbf{↘}$, and only those, appear at the beginning of the sign list, since they have non-numeric values⁵⁵. [Cat13, p. 58] has the numeric signs \mathbf{D} , $\mathbf{↘}$, \mathbf{I} , whereas non-numeric $\mathbf{—}$ is at the beginning of the sign list, where its values *aš* and *rum* are listed. For signs with both non-numeric and numeric usage, [Dei22] writes *s. die Zahlz.* throughout the main list; LAK 1 $\mathbf{—}$ thus reappears at LAK 829 together with \mathbf{D} , $\mathbf{↘}$, and \mathbf{I} . One should note [Bor10], which has numbers throughout the sign list; but that sign list does not show glyphs predating the Old Babylonian period, nor does it comprehensively cover the numerals used in the Ur III and Old Babylonian periods, as, for instance, it does not have $\mathbf{𐎶}$ – $\mathbf{𐎶𐎶}$ used in system $G_{\text{Ur III/OB}}$.

Composite texts rarely have witnesses both from the Early Dynastic period and later; the kinds of texts that do, chiefly lexical and literary texts, do not contain numbers to the extent that administrative texts do. Further, there tend to be changes⁵⁶ to the text between Early Dynastic and later witnesses that prevent a diachronic encoding of such composites. For numerals, the switch from \mathbf{D} to \mathbf{I} numerals prevents diachronic encoding even if \mathbf{D} were unified with $\mathbf{—}$. For instance, the lexical list Early Dynastic Food, already mentioned in section 3.5, contains some numbers, and has a witness from the Old Akkadian period covering these numbers: [P215653, a 1'–6']; however, they are written with \mathbf{I} numerals, whereas they are written with \mathbf{D} numerals in the Early Dynastic witnesses; since \mathbf{I} and $\mathbf{—}$ are distinct⁵⁷ characters, the $\mathbf{D}\mathbf{—}$ unification does not help.

More generally, since numbers are so deeply tied to metrology, and since metrological systems change between the Early Dynastic and later periods⁵⁸, there is little opportunity for a diachronic representation of numeric quantities.

In the case of analyses such as [Romach2023], it is interesting to note that numeric expressions are removed prior to the conversion of the corpus to Unicode cuneiform for further analysis.

⁵⁵Non-numeric values of $\mathbf{—}$ were discussed in section 3.5; $\mathbf{↗}$ has the values *man*₃ and *min*₅, and is used for the word *didli*, “several, various”; $\mathbf{↘}$ has the value *eš*₆.

⁵⁶TODO comment on the ED witnesses to the instructions of Šuruppak

⁵⁷Besides the contrasts in numeric usage mentioned in section 3.3.3, these characters are clearly not unifiable because of the many contrasts in non-numeric usage between them; several values of $\mathbf{—}$ which are not shared with \mathbf{I} have already been mentioned, but perhaps most striking is the fact that, in the Neo-Assyrian period, $\mathbf{—}$ is used for the preposition *ina*, “in”, and \mathbf{I} for the preposition *ana*, “to”.

⁵⁸TODO cite a few things here.

3.7 Compatibility considerations

A disunification twenty years after the fact, affecting all numerals, would ordinarily be a serious compatibility issue. Fortunately, with one exception discussed below, we are not aware of any font using curviform glyphs for the already-encoded numerals. In fact we are not aware of any font designed for a style earlier than Old Babylonian, except for fonts mimicking the representative glyphs from the code charts, which are primarily Ur III, but sometimes earlier or later, as described in [UTR56, §2.4]. The lack of dedicated Ur III fonts may be explainable by the chart-like fonts⁵⁹ being good enough for most purposes; the lack of Early Dynastic fonts, by the aforementioned issues with numeral unification making the representation of any text with numerals intractable.

3.7.1 The case of ŠAR₂

The character U+122B9 CUNEIFORM SIGN SHAR2 has a circular reference glyph.

In most texts from the Early Dynastic IIIb and Old Akkadian period⁶⁰, a contrast between non-numeric šar₂ written ◊ and numeric 1(šar₂) written ● can be observed, similar to the contrast between — and ▢ previously discussed in section 3.5. However, in lexical lists from Šuruppag and Ebla⁶¹, as well as in the *Stèle des vautours*, non-numeric šar₂ is curviform:

- * 𒌦 ◊ ● and * 𒌦 ● 𒌦 𒌦 in [P010566];
- ● 𒌦 and * ● 𒌦 in [P010576];
- ● 𒌦 [P240986];
- ● 𒌦 𒌦 in [P222399, obv. 17, 9, 18, 11, 22, 12]⁶².

It would be disruptive to the diachronic representation of text if non-numeric šar₂ were to have two different representations. The character U+122B9 CUNEIFORM SIGN SHAR2 should therefore be used in those cases, with its curviform glyph ●, identical to the glyph of (TODO: the proposed character). Since the archaizing style of texts wherein non-numeric šar₂ is curviform solidly predates the transition from ● to ◊ in the relevant metrological systems, there is no need to represent a ◊-● contrast, so these characters can have the same glyph.

Since cuneiform U+122B9 CUNEIFORM SIGN SHAR2 effectively merges with U+1212D ◊ CUNEIFORM SIGN HI, the reference glyph should remain as it is, *i.e.*, curviform, so that the contrast between reference glyphs remains clear; see [UTR56, §2.4]. Since system fonts follow the reference glyphs, and since extant specialist fonts target styles where U+122B9 is unambiguously cuneiform, there are no compatibility issues.

⁵⁹Most prominently Noto Sans Cuneiform, a system font on both Windows—as part of Segoe UI Historic—and macOS.

⁶⁰For example, in personal names:

- 𒌦 ◊ 𒌦 in [P020019] from ED IIIb Nirsu;
- 𒌦 ◊ 𒌦 𒌦 in [P020182], also from ED IIIb Nirsu;
- 𒌦 * ◊ in [P222186] from ED IIIb Umma;
- 𒌦 * 𒌦 ◊ in [P235312] from Old Akkadian Umma.

⁶¹TODO Mention other ways in which these are archaizing

⁶²Note however * 𒌦 ◊ 𒌦 on [P222399, obv. 6, 17]. Curviform non-numeric šar₂ is clearly archaizing in ED IIIb Nirsu; one might suppose that the scribe slipped into their modern ways here. TODO add a photo.

Note that in rare cases, such as [P222243] from ED IIIa Adab, non-numeric 𒍪 (here with the value rum) is written 𒍪 . It is out of scope for this proposal to decide whether such occurrences should be treated as anomalous spellings and encoded as (TODO: the proposed characters) or as stylistic distinctions and encoded as U+12038 CUNEIFORM SIGN ASH with a curviform glyph. in practice this would often be determined by the transliteration from which the cuneiform text is generated; it is noteworthy that as of this writing, the CDLI transliteration (UR2-1(aš@c)) and the ePSD2 one (uru₈^{rum}) of this word disagree on that aspect. Since 𒍪 has a cuneiform reference glyph, this does not pose any compatibility concerns.

3.7.2 Transliteration

An important feature of the encoding is that, in order to support input and bulk conversion of transliterated corpora to Unicode cuneiform, it should not represent distinctions that are finer than those recorded in typical transliterations; thus, while some older forms of BIL₂ can be described as $\text{𒍪} \times \text{𒍪}$ NE×KASKAL or $\text{𒍪} \times \text{𒍪}$ NE×PAP⁶³, they are typically all transliterated bil₂, and therefore are all represented by the character U+1224B 𒍪 CUNEIFORM SIGN NE SHESHIG, its name notwithstanding, as described in [UTR56, §2.5].

The situation is more complicated for numbers. Many transliterations do not represent the type of numeral used, instead interpreting the whole numeric expression and transcribing it with delimiters or units as needed to disambiguate. For instance, $\text{𒍪} \ll \text{𒍪} \text{𒍪}$ from [P305639] may be transliterated as 95 gur, as in [Feuerherm2004]. The numerals may also be transliterated separately, but solely by their values in terms of the overt unit, as in EbDA transliterations: the aforementioned $\text{𒍪} \text{𒍪} \text{𒍪} \text{𒍪} \text{𒍪} \text{𒍪} \text{𒍪} \text{𒍪} \text{𒍪} \text{𒍪}$ from [P240533, recto 3, 3] is transliterated “20-1-1/2 gu₂-bar 7 nig₂-sagšu 2-1/2 an-zam_x⁶⁴ za”, reading both 𒍪 and 𒍪 as 1/2, but not distinguishing them.

In particular, these transliterations do not differentiate between 𒍪 and 𒍪 numerals, nor between 𒍪 and 𒍪 numerals. For instance, the aforementioned $\text{𒍪} \text{𒍪} \text{𒍪} \text{𒍪} \text{𒍪} \text{𒍪} \text{𒍪} \text{𒍪} \text{𒍪} \text{𒍪}$ from [P242293, recto 4, 1] is transliterated “4 a₃-da-um^{tug₂}-II 4 aktum^{tug₂} 4 ib₂-III gun₃ sa₆^{tug₂}” in EbDA, with no distinction between the 𒍪 and 𒍪 . Since 𒍪 and 𒍪 numerals are separately encoded, the numeric expressions in such transliterations cannot be transformed into Unicode cuneiform without additional context, regardless of curviform-cuneiform unification.

In metrological systems such as systems $G_{\text{Ur III/OB}}$ and $C_{\text{Ur III/OB}}$ where some units are indicated by the type of numeral rather than an overt unit sign, it is common practice to add the unit in parentheses in transliteration; for instance, $\text{𒍪} \ll \text{𒍪} \text{𒍪} \text{𒍪} \text{𒍪}$ from [P386847] is transliterated “1(eše₃) 5½ iku⁶⁵ 7 sar” in [Feuerherm2004], and $\text{𒍪} \text{𒍪} \text{𒍪} \text{𒍪} \text{𒍪}$ from [P307255] is transliterated “1(n⁶⁶) 2(b) 7 ½ sila₃” in [Feuerherm2004].

This practice has been generalized to systematically indicate numeral shape; this is in particular the case in CDLI, where the transliterations of some the above examples are “1(gesz2) 3(u) 5(asz) gur” for $\text{𒍪} \ll \text{𒍪} \text{𒍪} \text{𒍪}$, “1(esze3) 5(iku) 1/2(iku) GAN2 7(disz) sar” for $\text{𒍪} \ll \text{𒍪} \text{𒍪} \text{𒍪} \text{𒍪}$, and “3(barig) 2(ban2) 7(disz) 1/2(disz) sila3” for $\text{𒍪} \text{𒍪} \text{𒍪} \text{𒍪} \text{𒍪}$. CDLI and ePSD2 both distinguish curviform from cuneiform numerals in transliteration: the length $\text{𒍪} \text{𒍪} \text{𒍪} \text{𒍪} \text{𒍪} \text{𒍪} \text{𒍪} \text{𒍪} \text{𒍪} \text{𒍪}$ from [P020129, rev. 2, 1]

⁶³As on [P249253].

⁶⁴As of this writing, EbDA actually has an-zam_x, with U+1D6A GREEK SUBSCRIPT SMALL LETTER CHI.

⁶⁵TODO say something about this reading

⁶⁶TODO comment on nigida.

is transliterated “6(gesz2@c) 3(u@c) {ninda}nindax(DU) 1/2(asz@c) 4(disz@t) gi” in CDLI, and “6(geš₂) 3(u) ^{ninda}ninda_x(DU) 1/2(aš) 4(diš) gi” in ePSD2. Another example is [Molina2014], which uses 1a for \neg , 1d for \uparrow , 1ac for \triangleright , 1dc or $\frac{1}{2}dc$ for ∇ depending on reading, etc. The literature on the Uruk and Early Dynastic I–II periods uses a different set of transliteration conventions that also disambiguate numeral shapes, as will be discussed in section 4.

While there exist transliterations that distinguish \neg from \uparrow but not \mathbb{B} from \neg , such as the ones used in [DCCMT], the trend, especially in more recent works in third millenium studies, seems to be to represent numeral shape; for example, [Maiocchi2024] gave an example of the input syntax used by the new “Urban Economy Begins” project as “10 + 5c(GUR) + 2(BARIGA) + 1(BAN2)” for $\bullet\mathbb{B}\uparrow+$, with a c indicating that the GUR numerals are curviform, and the parenthetical GUR indicating that these are \triangleright rather than ∇ numerals.

3.8 Conclusions

Co-occurrences of curviform and cuneiform numerals are not anecdotal in the Early Dynastic period. Instead, they represent contrasts between metrological systems, between individual units within metrological system, and between numeric usage and phonetic or logographic usage. This contrastive usage is reflected in modern publications.

While it would be technically possible to handle this contrast as a stylistic distinction, this is highly inconvenient, as it requires single numeric expressions to systematically use multiple fonts; further, if that contrast is lost in plain-text interchange, the text can be misinterpreted: \lll is a length of three ropes, but $\bullet\bullet$ is an area of three bur₃; $\triangleright\uparrow$ could be read as one $\mathbb{B}\nabla\downarrow$ and one $\nabla\uparrow\mathbb{B}\downarrow$, where $\mathbb{B}\nabla$ would be one and a half $\mathbb{B}\nabla\downarrow$; $\neg\mathbb{B}\downarrow$ is a personal name, but $\triangleright\mathbb{B}\downarrow$ would be “one slave”.

At the same time, contrary to most disunifications, the separate encoding of curviform numerals poses no serious compatibility issues for existing fonts or encoded corpora. The oddity of \bullet requires some explanation, but does not pose any architectural issues, and is not fundamentally different from the other mergers and splits encountered in the cuneiform script.

4 Rationale for ED–Uruk numeral unification

TODO mention the bariga silliness in the CDLI transliteration of Gori’s paper.

5 Considerations on individual numeral series

[TODO Document to the extent possible the metrological systems in which each sign is used. Note the disunification of N9 and N10 from 4(ban₂@c) and 5(ban₂@c).]

6 Characters not included in this proposal

6.1 Missing numerals

(N₁₇, 12N₁₄, etc.) 7(diš tenû)

6.2 Stacking patterns

(... are a mess, vary within Uruk, and are not transliterated/documented by Englund, so let's not go there for now.)

6.3 Matters for higher-level protocols

Rotated bits: <https://cdli.mpiwg-berlin.mpg.de/artifacts/101087>

Acknowledgements

TODO(egg): Something about the Vanséveren fonts

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