

# Archaic cuneiform numbers

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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 script<sup>1</sup> and the proto-cuneiform script<sup>2</sup>. 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”, numerals<sup>3</sup> should however *not* be unified with the already-encoded cuneiform numerals<sup>4</sup>. 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		
			Existing Xsux
Non-numeric signs	Future Pcun		

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

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

<sup>2</sup>ISO 15924: Pcun, not yet encoded.

<sup>3</sup> 𐎶 1-9(aš<sup>c</sup> = N<sub>1</sub>), 𐎷 1-5(u<sup>c</sup> = N<sub>14</sub>), 𐎸 1-9(ḫeš<sub>2</sub><sup>c</sup> = N<sub>34</sub>), 𐎹 1-5(ḫeš<sup>c</sup>u<sup>c</sup> = N<sub>48</sub>), etc.

<sup>4</sup> 𐎶 1-9(aš), 𐎷 1-5(u), 𐎸 1-9(ḫeš<sub>2</sub>), 𐎹 1-5(ḫeš<sup>c</sup>u), 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 Šuruppag as in the character code charts,  later in the third millenium<sup>5</sup>,  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 lists<sup>6</sup> and dictionaries<sup>7</sup>, and of composite texts<sup>8</sup>. 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]<sup>9</sup>. The diachronic approach is also useful for pedagogic applications<sup>10</sup>.

### 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 encoding<sup>11</sup> 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:




















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<sup>5</sup>Merging with U+1224E  NI<sub>2</sub>.

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



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

<sup>8</sup>For example, there are Neo-Assyrian and Neo-Babylonian copies parts of the laws of                                                         

                                                          

                                                          

                                                          

                                                          

                                                          

            

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



The argument made in [L2/04-099, p. 4] is that this is comparable to a stylistic distinction such as<sup>15</sup>


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;

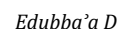
<sup>12</sup>As noted in [Pow87, p. 466], this sign has a very short “tail” in this period, so that it is wider than it is tall, and can at first seem like a large  in copies. The photos in CDLI clearly show that this is in fact a vertical wedge.

<sup>13</sup>Note 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 .

<sup>14</sup>Transliteration after [Lec20, p. 8].

<sup>15</sup>We 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.

- ### 3.3 A primer on classic Ur III and Old Babylonian metrologies



As is well known<sup>16</sup> a sexagesimal place value system (SPVS) was used in Mesopotamia from the late third millenium 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  $\text{I}$ – $\text{III}$ , the multiples of ten (10–50) are  $\text{<}$ – $\text{X}$ , but the other digits 11–59 are sequences  $\text{<I}$ – $\text{XIII}$ ; 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*  $\mathcal{S}_{\text{Ur III/OB}}$ , which had different signs for the units  $\text{I}$ – $\text{III}$ , tens  $\text{<}$ – $\text{X}$ , sixties  $\text{I}$ – $\text{XIII}$  (with larger wedges than the units), six hundreds  $\text{K}$ – $\text{XK}$ , three thousand six hundreds  $\text{D}$ – $\text{XXK}$ , and thirty-six thousands  $\text{D}$ – $\text{XXK}$ .

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

5



Observe that while large numbers of gur follow<sup>23</sup> system  $S_{Ur\ III/OB}$ , the use of horizontal (AŠ) numerals for the gur disambiguates from the vertical bariga, as <|𐎶| would be 10 gur 1 bariga, and <𐎶-𐎶| would be 11 gur; again even with some overt units, most of the numerals that participate in a metrological system have an interpretation dependent on that system.

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

- |𐎶-𐎶 used in  $S_{Ur\ III/OB}$  and the SPVS as well as with overt units;
- <-𐎶𐎶 used in  $G_{Ur\ III/OB}$ , of which <-𐎶 are also used in  $S_{Ur\ III/OB}$  and the SPVS as well as with overt units;
- |𐎶-𐎶𐎶 used in  $S_{Ur\ III/OB}$ , and sometimes with overt units;
- 𐎶-𐎶 used in  $S_{Ur\ III/OB}$ ;
- 𐎶-𐎶𐎶𐎶 used in  $S_{Ur\ III/OB}$  and  $G_{Ur\ III/OB}$ ;
- 𐎶-𐎶𐎶𐎶 used in  $S_{Ur\ III/OB}$  and  $G_{Ur\ III/OB}$ ;
- 𐎶-𐎶𐎶𐎶 used in  $C_{Ur\ III/OB}$  as well as with overt units of the weight system;
- 𐎶, 𐎶, 𐎶, 𐎶, 𐎶 used in  $C_{Ur\ III/OB}$ ;
- |, |, |, | used in  $C_{Ur\ III/OB}$ —note the overlap with |𐎶-𐎶;
- 𐎶 and 𐎶 used in  $G_{Ur\ III/OB}$ .

Only in the SPVS did numerals exist truly independently of metrology; to quote [Rob08, p. 78]: “The SPVS temporarily changed the status of numbers from properties of real-world objects to independent entities that could be manipulated without regard to [...] metrological system. [...] Once the calculation was done, the result was expressed in the most appropriate metrological units and thus re-entered the natural world as a concrete quantity.”

### 3.3.4 The length system

In the Ur III and Old Babylonian periods, lengths are expressed using overt units counted with | and < numerals with their system  $S_{Ur\ III/OB}$  values<sup>24</sup>. Since it does not have any unusual numerals, this system would not in itself be of much relevance to character encoding, but we present it here as background for its Early Dynastic counterpart presented in section 3.4. Metrological tables use the following units [Fri07, p. 118; Rob19]:

𐎶𐎶𐎶𐎶	← 60	𐎶𐎶	← 10	𐎶𐎶	← 12	𐎶𐎶	← 30	𐎶𐎶𐎶𐎶	( $L_{Ur\ III/OB}$ )
danna		US <sup>25</sup>		nindan		kuš <sub>3</sub>		šu-si	
bērum		cable		nindanum		ammatum		ubānum	
league		360 m		rod		cubit		finger	
10,8 km				6 m		50 cm		17 mm	

Two more units appear occasionally [Pow87, p. 459; Fri07, p. 118; Rob19]:

𐎶𐎶𐎶𐎶	← 30	𐎶𐎶	← 6	𐎶𐎶	← 10	𐎶𐎶	← 2	𐎶𐎶	← 6	𐎶𐎶	← 30	𐎶𐎶𐎶𐎶	( $\bar{L}_{Ur\ III/OB}$ )
				eše <sub>2</sub>		gi		qānum					
				ašlum		reed		3 m					
				rope									
				60 m									

<sup>22</sup>From [P309594].

<sup>23</sup>A larger unit, the guru<sub>7</sub> (karûm, grain heap), is sometimes used instead, with 𐎶𐎶𐎶𐎶𐎶𐎶𐎶 (1 karûm = 3600 kurrû). See [Fri07, p. 415; Rob19].

<sup>24</sup>Adjacent units are no more than a factor of 60 apart, so higher numerals such as 𐎶 or 𐎶 are not used.

<sup>25</sup>TODO

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  $\text{D}$  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  $10\bullet$  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  $\text{D}$  is generally omitted; in addition, only tens of rods are used; these are equal to one rope, but the sign  $\text{D}$  is not written either. Length shorter than one rope are expressed in half-rope using the  $1/2$  sign  $\text{D}$  (again with no  $\text{D}$ ), and then in reeds, *with* the sign  $\text{D}$ . 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 numerals<sup>29</sup>; in the absence of overt units, such as when dealing with length that

<sup>28</sup>Note that the reeds are counted using *tenû* numerals,  $\text{D}$ ,  $\text{D}$ ,  $\text{D}$ , etc.

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



### 3.4.2 Dyke lengths in Nirsu

— [P221305, obv. 1, 4]<sup>32</sup>

— [P020129, rev. 2, 1]

— [P221291, rev. 5, 1]<sup>33</sup>

— [P221266, rev. 2, 1]

$$\underbrace{\text{E} \xleftarrow{10} \text{D} \xleftarrow{6} \bullet}_{\text{Ib}} = \underbrace{\text{D} \xleftarrow{2} \text{F}}_{\text{35}} \xleftarrow{10} \text{A} \xleftarrow{6} \text{B} \xleftarrow{3} \text{C} \xleftarrow{1} \text{D} \xleftarrow{1} \text{E} \quad (L'_{\text{ED IIIb}})$$

<sup>30</sup>This is the case of the sides of the field in [P020054, obv. ii 2–3].






<sup>32</sup>CDLI only has a copy, but a photo may be found in [Lec12, p. 82]. On that photo the  $\text{𒀭} \text{𒀪} \text{𒌦}$  is not visible. Lecompte notes that the copy is faithful; indeed another  $\text{𒀭} \text{𒀪} \text{𒌦}$  can be seen both on the copy and the photo on obv. 2, 2.

<sup>33</sup>From copy.

<sup>34</sup>TODO Cite also DP 568, the one with  and  even though it has no reeds.

<sup>35</sup>TODO(egg): Note that one unit may be omitted if the other is present

The system of grain<sup>36</sup> capacities in Ebla uses the following units<sup>37</sup>:

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

gu<sub>2</sub>-bar      ba-ri<sub>2</sub>-zu      nin<sub>4</sub>      nin<sub>2</sub>-sagšu      an-zam<sub>x</sub>

The  $\text{𐎧𐎠𐎵}$  and  $\text{𐎧𐎠𐎵𐎠𐎵}$  are generally counted using curviform numerals, and the smaller units using cuneiform  $\text{𐎶}$  numerals. Indeed, a search on [Mil+07] for co-occurrences of  $\text{𐎶𐎶𐎶}$  with either of  $\text{𐎧𐎠𐎵}$  or  $\text{𐎧𐎠𐎵𐎠𐎵}$  finds the following expressions<sup>38</sup>:

1. [P240532, verso 4, 9]  <sup>40</sup>
2. [P240548, verso 1, 1] 
3. [P240655, recto 7, 9]  <sup>41</sup>
4. [P240579, verso 4, 3] 
5. [P240675, verso 2, 2] 
6. [P240609, verso 3, 1] 
7. [P240533, recto 3, 3]  <sup>42</sup>
8. [P240697, recto 1, 5] 
9. [P240653, recto 6, 2] 
10. [P240654, recto 2, 6]  <sup>43</sup> <sup>44</sup>
11. [P240531, recto 1, 8] 
12. [P241708, recto 1, 1] <sup>45</sup> 
13. [P241904, recto 1, 1] <sup>46</sup>  <sup>47</sup>

Note that higher numbers of  $\text{𒌦}$  are expressed in hundreds (*mi-at*  $\text{𒈹𒍪}$ ) and then thousands (*li-im*  $\text{𒂊𒌦}$ ), as is typical in Ebla [Arc15, p. 33], e.g., in [P240532, verso 2, 3],  $\text{𒂊𒈹𒍪𒀭𒃶𒄁𒌦}$  (100 + 60 + 30 + 5 = 195  $\text{𒌦}$  of grain).




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

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

[illegible]

but we have not investigated this thoroughly.

<sup>37</sup>TODO mention the other one citing Chambon and the footnote in Archi

<sup>38</sup>We cite here only one attestation per tablet; most tablets contain several expressions mixing cursive   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 checked<sup>39</sup> on a photograph (from EbDA unless noted otherwise).

<sup>39</sup>As we will see in Section 3.6.1, 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.

<sup>40</sup>ba-ri<sub>2</sub>-zu<sub>2</sub>, a variant spelling.

<sup>41</sup>Short for  $\Box \Diamond \bot$ .

<sup>42</sup>Note the omitted  $\square \downarrow$ .

<sup>43</sup>Instead of the expected  $\mathbb{P}^1 \times \mathbb{P}^1$ .

<sup>44</sup>  not legible on the EbDA photo.

<sup>45</sup>From CDLI photo.

<sup>46</sup>From photo in [Arc89, p. 6].

<sup>47</sup>Laid out as  $\begin{bmatrix} | & | & | \\ | & | & | \end{bmatrix}$ ; on stacking patterns see Section 6.2.



formed by only two signs  $\Upsilon$  and  $\triangleleft$ , 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, 60, 60<sup>2</sup>, 60<sup>3</sup>, 1/60, 1/60<sup>2</sup>, etc. are written in the same way, with the vertical wedge  $\Upsilon$ . 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:  $\Upsilon\Upsilon\Upsilon\Upsilon\Upsilon\Upsilon$  but never with the repetition  $\Upsilon\Upsilon\Upsilon\Upsilon\Upsilon\Upsilon$ .

Figure 5: TODO [Cha12, p. 59]<sup>50</sup>

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:

$\Upsilon\Upsilon\Upsilon$  še bar  $\Upsilon$  ba-rí-zu  
‘3 gubar (capacity units) and 1 parisu’.

Figure 6: TODO [Cha12, p. 61]

This is particularly true of the signs  $\Upsilon$ ,  $\Upsilon$ ,  $\Upsilon$  and  $\Upsilon$ , whose form explicitly denotes the fractions 1/6, 2/6, 3/6, and 4/6 of the barig capacity measure written  $\Upsilon$  in Mesopotamia—also transcribed by Assyriologists as 1 bán, 2 bán, 3 bán, and 4 bán with reference to the bán measure worth 1/6 of the barig. At Ebla, the sign  $\Upsilon$  is most often associated with the *parisu* measure, while the signs  $\Upsilon$ ,  $\Upsilon$ ,  $\Upsilon$  and  $\Upsilon$  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.,  $\Upsilon\Upsilon\Upsilon\Upsilon\Upsilon\Upsilon$  transliterated as 2(šar<sub>2</sub>) 1(geš’u) 3(u), means 2 × 3600 + 1 × 600 + 3 × 10). The system is based on an alternation of factors ten and

Figure 8: TODO

might think of one fabric and a half,<sup>11</sup> but the presence of notations with “2 $\Upsilon$  2 $\Upsilon$ ”, “3 $\Upsilon$  3 $\Upsilon$ ”, and “6 $\Upsilon$  6 $\Upsilon$ ” (Fig. 1) elements excludes that one deals with fractions, as these notations are not consistent with those of Šuruppag’s weight measurement system.<sup>12</sup> The notation “1 $\Upsilon$  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  $\Upsilon$  and  $\Upsilon$  numerals in [Gor23, p. 162].



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














9











..

in the aforementioned administrative texts; a line  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  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  together with , while , , and , and only those, appear at the beginning of the sign list, since they have non-numeric values<sup>55</sup>. [Cat13, p. 58] has the numeric signs , , , whereas non-numeric  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  thus reappears at LAK 829 together with , , and . 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 – used in system *G<sub>Ur III/OB</sub>*.





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 changes<sup>56</sup> to the text between Early Dynastic and later witnesses that prevent a diachronic encoding of such composites. For numerals, the switch from  to  numerals prevents diachronic encoding even if  were unified with . 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  numerals, whereas they are written with  numerals in the Early Dynastic witnesses; since  and  are distinct<sup>57</sup> characters, the – 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 periods<sup>58</sup>, 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.

<sup>55</sup>Non-numeric values of  were discussed in section 3.5;  has the values *man*<sub>3</sub> and *min*<sub>5</sub>, and is used for the word *didli*, “several, various”;  has the value *eš*<sub>6</sub>.

<sup>56</sup>TODO comment on the ED witnesses to the instructions of Šuruppak

<sup>57</sup>Besides 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  which are not shared with  have already been mentioned, but perhaps most striking is the fact that, in the Neo-Assyrian period,  is used for the preposition *ina*, “in”, and  for the preposition *ana*, “to”.

<sup>58</sup>TODO cite a few things here.

### 3.6.1 Compatibility with transliteration

TODO words [Robo8, p. 295] TODO cite [Molina2014]

## 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 fonts<sup>59</sup> 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 ŠAR<sub>2</sub>

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

In most texts from the Early Dynastic IIIb and Old Akkadian period<sup>60</sup>, a contrast between non-numeric šar<sub>2</sub> written ◊ and numeric 1(šar<sub>2</sub><sup>c</sup>) written ● can be observed, similar to the contrast between — and ▢ previously discussed in section 3.5. However, in lexical lists from Šuruppak and Ebla<sup>61</sup>, as well as in the *Stèle des vautours*, non-numeric šar<sub>2</sub> is curviform:

- \*𒌦◊● and \*𒌦●𒌦 in [P010566];
- ●𒌦 and \*●𒌦 in [P010576];
- ●𒌦◊ in [P222399, obv. 17, 9, 18, 11, 22, 12]<sup>62</sup>.

It would be disruptive to the diachronic representation of text if non-numeric šar<sub>2</sub> 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 šar<sub>2</sub> 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 the same 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.

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

<sup>60</sup>For example, in personal names:

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

<sup>61</sup>TODO Mention other ways in which these are archaizing

<sup>62</sup>Note however \*𒌦◊◊ on [P222399, obv. 6, 17]. Curviform non-numeric šar<sub>2</sub> is clearly archaizing in ED IIIb Nirsu; one might suppose that the scribe slipped into their modern ways here.

Note that in rare cases, such as [P222243] from ED IIIa Adab, non-numeric  $\text{𒀭}$  (here with the value rum) is written  $\text{𒀭}$ . 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 (uru<sub>8</sub><sup>rum</sup>) of this word disagree on that aspect. Since  $\text{𒀭}$  has a cuneiform reference glyph, this does not pose any compatibility concerns.

### 3.8 Conclusions

Mention something about potential for confusion in character identity.

## 4 Rationale for ED-Uruk numeral unification

## 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(ban<sub>2</sub>@c) and 5(ban<sub>2</sub>@c).]

## 6 Characters not included in this proposal

### 6.1 Missing numerals

(N<sub>17</sub>, 12N<sub>14</sub>, 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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