L2/13-226

Arabic Amphibious Characters

phonetics, phonology, orthography, calligraphy and typography

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I. Summary

Contemporary Qur'ānic Orthography (CQO), introduced with the 1924 Cairo recension of the Qur'ān[1], differs from Modern Standard Arabic (MSA) and Ottoman Qur'ānic orthography in two respects:
1. Letters, that are missing from the basic text skeleton, are inserted in miniature form, independent of existing letter groups.
2. In combination with long vowels after glottal stop (*hamz),* a spelling principle is used that, unlike MSA or Ottoman Qur'ān orthography, does not reflect the sound shift that had originally eliminated glottal stop from Arabic.

These differences led to the addition of graphemes *between* tradional letters or letter blocks, resulting in:
a. spellings that cannot be attested in manuscripts in the pre-typographic *naskh* script style;
b. script structures that are not covered by computer typography, forcing improvised solutions and tweaking of the Unicode[2] data format when reproducing the "Cairo orthography".

Additional graphemes, that involve horizontal sequences of diacritical attachments, are identified as *amphibious letters*, because their category as letters is between skeleton letters and diacritic letters, while their position in text is between skeleton letters and not above or below them. In scholarship this category is unknown and there is no support for them in the information technology industry: there exists no unambiguous encoding norm in UNICODE. This affects text critical Qur'ānic studies and the correct typesetting of Qur'ān text.

1 This essay focuses on the 1924 spelling of the Qur'ān recension, also known as *The King Fu'ād Qur'ān*. Its spelling prevails all over the Arabic world; it is referred to here as Contemporary Qur'ānic Orthography.

2 *The Unicode Standard 5.0*, The Unicode Consortium 2007.

II. Corrective vs. supplementary diacritics

a. Basic principles of Arabic orthography

Arabic orthography is essentially morpho-phonologic. The phonologic aspect means that each phoneme is adequately rendered, without covering phonetic detail. For instance, in the phonemic opposition /ṣūrä : sūrä/, which phonetically involves more, collateral sound changes [ṣõṛå : sūra], the operative contrast is that of /ṣ:s/. This linguistic structure is precisely rendered in Arabic orthography, irrespective of redundant additional changes.

fig 1. Phonological spelling: only significant sounds are rendered.

pharyngealization	phonemic contrast	example	orthography	operative grapheme
+	/ṣ/	*ṣūrä*	صورة	ص
-	/s/	*sūrä*	سورة	س

The morphologic aspect of this morpho-phonologic principle is the strategy to retain a stable spelling for certain morphemes, i.e., grammatical particles, *irrespective* of their pronunciation. For instance, the spelling of the definite article remains *ʾalif-lām*, even in cases where *lām* is absorbed into the following consonant, whose resulting gemination then expresses the article. This morphologic structure is overruled when full vowelling is in place: *al-šams* الشمس becomes phonologic *š-šams* اَلشَّمْس.

fig 2. Morphologic spelling: not the sound, but the morpheme is rendered.

assimilation	morpheme	example	orthography	operative graphemes
+	{l-}	*š-šams*	الشمس	ال
-	{l-}	*l-qamar*	القمر	ال

In most cases orthography applies the phonologic principle also on morphemes. That means that it reflects the assimilations if they produce another standard phoneme. E.g., the inserted morpheme {-t-} in the particple of measure VIII muC[1]{-t-}aC[2]aC[3] of the verb:

fig 3. Phonologic spelling: not the morpheme, but the sound is rendered.

assimilation	morpheme	allomorph	orthography	operative grapheme
+	{-t-}	*ṭ: muṣṭafà*	مصطفى	ط
-	{-t-}	*t: murtaḍà*	مرتضى	ت

The 1924 Cairo recension presents exhaustive phonetic detail not known from Ottoman Qur'āns, based on North African manuscript practice. The resulting orthography, fully vowelled and can be considered phonetic.

fig 4. Phonetic spelling: semantically redundant sound detail is rendered.

assimilation	morpheme	example	orthography	operative grapheme(s)
-	{-n}	Q34:23 *hudà-n ʾaw*	هُدًى أَوْ	ً
+	{-n}	Q2:97 *hudà- wa*	وَهُدًى وَ	ً
+	{-n}	Q2:38 *hudà- fa man*	هُدًى فَمَن	ً
+	{-n}	Q2:2 *hudà-l li l-muttaqīna*	هُدًى لِّلْمُتَّقِينَ	ّ◌ً
+	{-n}	Q22:67 *hudà-m mustaqīmi-n*	هُدًى مُّسْتَقِيمٍ	ّ◌ً

b. Corrective diacritics

Arabic orthography is very consistent, but in the transmission of the Qur'ān a few cases of allophonic spelling have slipped in. Their numbers are limited, but the way they are corrected show the principle of superimposed *corrective diacritics* in Arabic grapheme structure. Corrective diacritics are placed above or below the erroneous letter without affecting the skeleton.

fig 5. Allophonic spelling, corrected by superscripted miniature:

assimilation	allophone	example	orthography	operative diacritic
+	[ṣ]	*baṣṭä* Q7:69	بَصْطَة	◌ِ ص
-	[s]	*basṭä* Q2:247	بَسْطَة	س

fig 6. Syllabic assimilation, corrected by subscripted miniature:

assimilation	allophone	example	orthography	operative diacritic
+	[ṣ]	*l-muṣayṭirūna* Q52:37	ٱلْمُصَيْطِرُونَ	◌ِ ص
-	[s]	*l-musayṭirūna* MSA	ٱلْمُسَيْطِرُونَ	س

This last misspelling, a single case, candidly confirms that Richard S. Harrell's *phonetic analysis of Egyptian Radio Arabic*[3], where he observes that though the minimum unit of pharyngealisation is a single syllable but that adjacent syllables are also affected, must have been valid for a much earlier stage of Arabic.

c. Supplementary diacritics

In a limited number of cases letters were really lost in transmission. These are discretely supplemented by means of an inline miniature of the missing letter. The *supplementary diacritic* occurs in two distinct graphic environments, the *continuous* and the *discontinuous* one. In the discontinuous case the inserted character can simply be placed between interrupted letters. In the continuous case, the supplementary diacritic, being a missing letter, needs to be accommodated between skeleton letters, sometimes even carrying its own diacritic. In either situation, these corrections are illustrations of *amphibious letters*.

3 Harvard University Press 1960.

fig 7. Inserting an amphibious letter between interrupted letters:

transcription	MSA	defective CQO	supplement
īlāfihim Q106:2	إِيلَٰفِهِمْ	إِـٰلَفِهِمْ	ے

fig 8. Inserting an amphibious letter between uninterrupted letters:

transcription	MSA	defective CQO	supplement
li yasuʾû Q17:7	لِيَسُوٓءُوا	لِيَسُٓـُٔوْا	و

fig 9. Inserting an amphibious letter in final position:

transcription	MSA	defective CQO	supplement
yastaḥyī Q2:26	يَسْتَحْيِۦ	يَسْتَحِۦ	ے

A unique example is the missing *nūn* in *sūrä al-anbiyāʾ*. In an apparent inconsistency, the meticulous Cairo recension omits *sukūn* on top of the corrective miniature: نُجِّى. corresponding with نُنجِّى as can be found in Ottoman codices. The omission is, however, perfectly in line with the Cairo recension because it uses *ḥarakāt*, vowel diacritics, to express *taǧwīd*, phonetical detail. Omitting *sukūn* is a device to represent the phonetic, and therefore semantically neutral, assimilation between the phoneme /n/ and following dental consonants.

fig 10. Inserting an amphibious letter between uninterrupted letters:

transcription	MSA	defective CQO	supplement
nunǧī Q21:88	نُنجِّى	نُجِّىْ	ن

III. Glottal stop: amphibious *hamzä* replaces archaic *alef*

Regarding the spelling of the glottal stop in Arabic, W. Wright, in his seminal *Grammar of the Arabic Language*[4], describes the *hamzä* rule that to this day is taught everywhere as…

> "…a convenient formula [that] cannot well be improved upon without reference to the history of the Arabic language and writing, a consideration that may lay quite beyond the scope of the native systematic grammarians, to whose methods of exposition this work, for good practical reasons, is closely conformed. But from a historical point of view when we consider the cases where hèmza is expressed by ؤ, ئ, or by ء alone without a *kursī*, or supporting letter, we must distinguish between two pronunciations—that indicated by the consonants alone, which in the oldest times where written without any supplementary signs, and that indicated by the later points, such as ء. It is known that the people of the Ḥiğāz in the time of Mohammed gave up the original gutteral sound of hèmza in very many cases where the other Arabs still preserved it. Now the rules of Arabic ortography were mainly fixed by the Ḳor'ān, which was originally written down in the Ḥiğāz in accordance with the local pronunciation. This pronunciation did not ultimately prevail over the Arabic area, but the old orthography could not lightly be tampered with, having the character of a sacred tradition. The first scribes wrote بوس, جيت, جاك [5] because they said *bawusa, ğīta, ğāka* (or nearly so). The pronunciation, however, that prevailed was *ba'usa, ği'ta, ğā'aka* and this was expressed, without touching the old consonants, by writing بِئْتَ, بِؤْسَ, جَاءَكَ. Rules for writing hèmza as ؤ, ئ, or ء are therefore really rules for preserving the old gutteral ', in cases where it was already lost or transformed by the first scribes of the Ḳor'ān." (note to §134)

This quote, which is still representative of linguistic thinking among the majority of Arabists, explains that *A Grammar of the Arabic Language* is consciously unhistoric, in order to follow traditional grammarians as closely as possible. What then follows is a brief sketch where two consecutive phases in the development of Arabic pronunciation are presented as synchronous

4 First edition 1859, an expanded English translation of C.P. Caspari's *Grammatik der arabischen Sprache für akademische Vorlesungen*, 1844-48.

5 Sic! Typographic limitations may have precluded the use of letters "without any supplementary signs": بوس, حب, حاك.

instead of diachronous. The scenario, where later scribes corrected–and thus changed–what would have been the Prophet's very own Arabic, is so contradictory to the claim of uninterrupted, unchanged oral transmission of the Qur'ān, that it needs to be treated with scepticism.

An important part of this account is that "the old orthography could not lightly be tampered with, having the character of a sacred tradition". It implies that, though *could* be tampered with, it was mainly sacred. Today, Islamic calligraphy represents that sacred tradition in writing, focusing on the perfect image of the word, whereas Contemporary Qur'ānic Orthography continues the oral tradition, focusing on phonetic detail of the pronunciation.

In the evolution of Arabic orthography, the letter (diacritic) *hamzä* was a late addition. It only appeared after the introduction of vowels (which in turn appear later than the consonant disambiguation points). This is why *hamzä* and the letters that are composed with it are not counted in the traditional presentation of the Arabic alphabet as 28 letters.

In non-classical Arabic, the glottal stop, which in Semitic alphabets was always written with *'alif,* has disappeared except in word-initial position. The glottal stop had been subjected to a sound-shift according to the following pattern[6]:

fig 11. The sound shift that removes Arabic glottal stop in non-initial position

sound shift of glottal stop	example	reconstructed → Qur'ānic
a' → ā	*ra's* → *rās*	*راس → راس
i' → ī	*bi'r* → *bīr*	*بار → بير
u' → ū	*bu's* → *būs*	*باس → بوس
u'ū → ū	*ru'ūs* → *rūs*	*راوس → روس

6 adapted from W. Fischer, *Grammatik des klassischen Arabisch*, §14

sound shift of glottal stop	example	reconstructed → Qurʾānic
aʾa → ā	*saʾal* → *sāl*	سال → سال*
uʾā → uwā	*suʾāl* → *suwāl*	سوال → سال*
āʾi → āyi	*qāʾim* → *qāyim*	قایم → قام*
īʾ → iyy	*ḥaṭīʾä* → *ḥaṭiyyä*	حطیه → حطاه*
Cʾ → C (final)	*badʾ* → *bad*	بدء → بدا*
Cʾ → C (non-final)	*masʾalä* → *masalä*	مسئله → مساله*
wʾ → ww	*sawʾä* → *sawwä*	سوّئه → سواه*
āʾ → ā	*samāʾ* → *samā*	سماء → سما*
yʾ → yy	*barīʾ* → *bariyy*	بریء → بریا*
ūʾ → ū	*sūʾ* → *sū*	سوء → سوا*

In the postulated Arabic spelling of the non-classical examples in the table, *ʾalif* is used for glottal stop throughout. On the other hand, the long vowel /ā/ is not spelled with *ʾalif* in the reconstructed forms. The combination of these two deviations accounts for spellings like قام* for *qāʾim* (while *qāma* is spelled قﻮ*). The asterisk in front indicates that such forms are postulated and not necessarily attested, though Dr G.-R. Puin has found such cases in early Qurʾān manuscripts. E.g., a trace of this orthography can be seen in archaic Qurʾān manuscrips where *qāla* is spelled قل. The sound change *raʾs* → *rās* caused *ʾalif* to be interpreted as /ā/ instead of /ʾ/: راس. That change introduced a new value for *ʾalif*, that may account for the transition from spellings like قل to spellings like قال for *qāla*. Such variations suggest that orthography was still in flux when the Qurʾān was put in writing.

Another case of possible internal evicence is *bura'ā'u* (Q60:4) CQO بُرَءَآؤُاْ, MSA بُرَآءُ. The underlying structures are روا [BRW A] and را [BR A] respectively, from where a shift *bura'ā'u* → *burāwu* → *burā'* can be postulated. The /w/, which takes the place of elided /'/ if there is a adjacent rounded vowel /u/ or /ū/, suggests that final vowels were still pronounced at the time of the disappearance of glottal stop: روا. The later spelling which reintroduces glottal stop with a new, unambiguous diacritic grapheme, is based on an elided terminal vowel, hence there is no longer a *wāw* in the skeleton word: را.

A sound shift caused by loss of glottal stop is a common linguistic phenomenon. Depending on the phonetic context, the glottal stop either disappears or is replaced by a glide- or geminating an existing glide–between the surrounding adjacent vowels. A close parallel of this mechanism can be seen in spoken Dutch, where glottal stop /'/ is replaced by the glide /w/ with a neighbouring rounded vowel and by the glide /y/ with a neighbouring unrounded vowel:[7]

fig 12. Analogous case: the disappearance of glottal stop in Dutch phonology

roundedness	sound shift	Dutch in orthography	histrionic → colloquial
+	' → w	*doet u het*	dútü'ət → dútüwət
-	' → y	*doet hij het*	dúti'ət → dútiyət

Incidentally, the same example also parallels the disappearance of glottal stop after consonant in the sequence t'ü→tü (*dút'ü'ət → dútü'ət) and t'i→ti, (*dút'i'ət → dúti'ət) analoguous to C' → C in the Arabic table above. Non-classical and Classical Arabic today still exist side by side like histrionic and colloquial Dutch, in the form of MSA and spoken Arabic. Therefore the archaic deglottalized and the classic reglottalized forms both survive in modern (colloquial vs. standard) Arabic.
Classical Arabic orthography, to which MSA orthography essentially con-

7 Cf. *Fonologie van het Nederlands en het Fries*, A. Cohen, C.L. Ebeling, K. Fokkema, A.G.F van Holk, 's Gravenhage 1971, Hoofdstuk IV, De distributie der fonemen. In Dutch glottal stop /'/is marginal and not listed as a phoneme in the quoted study, but on page 86 of this chapter on phoneme distribution an interesting clue is given: /h/ cannot occur before /ə/. Therefore, when the vowel of the unaccented definite neutral article *het* /hɛt/ is reduced from /ɛ/ →/ə/, then /h/ is dropped–and in initial position automatically replaced with /'/.

forms, is built on top of these evolved forms by means of a corrective diacritic that reinstates the lost glottal stop.

One can surmise that a correction or reversal by reintroducing *ʾalif* as the letter for glottal was no longer feasible, because:
1. *ʾalif* was now wide-spread use to represent /ā/, and
2. *ʾalif*'s place inside words had been taken by successors in the form of the glide letters W and Y.

Consequently a new solution was created, not in the form of a letter, but in the form of a diacritic. It is placed above or below the replacement glide letters (corrective diacritic), or inline when the glottal stop disappeared without trace (suppletive diacritics). The resulting hybrid orthography can be illustrated with the same examples as used above:

fig 13. Glottal stop is reintroduced on top of or between letters

example	*ʾalif* as glottal stop	glottal stop replaced or lost	superimposed or inserted *hamzä*
raʾs → rās	*راس	راس	رأس
biʾr → bīr	*بار	بر	بئر
buʾs → būs	*باس	بوس	بوْس
ruʾūs → rūs	*راوس	روس	رءوس
saʾal → sāl	*سال	سال	سأل
suʾāl → suwāl	*سال	سوال	سؤال
qāʾim → qāyim	*قام	قام	قائم
ḫaṭīʾä → ḫaṭiyyä	*حطاه	حطه	خطيئة

example	*ʾalif* as glottal stop	glottal stop replaced or lost	superimposed or inserted *hamzä*
badʾ → bad	*بدا	بد	بدء
masʾalä → masalä	*مساله	مسله	مسئلة
sawʾä → sawwä	*سواه	سوه	سوءة
samāʾ → samā	*سما	سما	سماء
barīʾ → bariyy	*ريا	ری	بریء
sūʾ → sū	*سوا	سو	سوء

Traces of the postulated spelling of glottal stop as shown in the table above are encountered in the corpus of surviving early manuscripts. But even the CQO of the Cairo recension preserves some fascinating examples[8]:

fig 14. Doublets evidence phonological evolution of Arabic

example	*ʾalif* as glottal stop	glottal stop replaced or lost	superimposed or inserted *hamzä*
l-malaʾu / l-malawu	ٱلْمَلَأُ	الملو* → الملا	ٱلْمَلَؤُا۟
l-malaʾi: / l-malāyi	ٱلْمَلَإِ	مليه* → الملا	مَلَإِيْهِ ے
malaʾahu: / malāhu	مَلَأَهُۥ	ملاه = ملاه	مَلَأَهُۥ

ٱلْمَلَأُ occurs 12 times: Q7:60, Q7:66, Q7:75, Q7:88, Q7:90, Q7:109, Q7:128, Q11:27, Q12:43, Q23:33, Q28:38, Q38:6.

8 The *ʾalif* preceding or following the modern spellings are discussed in DR. GERD-R. PUIN, *Vowel Letters and Ortho-epic Writing in the Qurʾān* in *The Qurʾān in Its Historical Context 2* , ed. Gabriel S. Reynolds, Routledge 2009, forthcoming.

ٱلْمَلَإِ occurs 3 times : Q2:248; Q37:8, Q38:69.

مَلَأَهُۥ occurs once : Q10:88.

ٱلْمَلَؤُاْ occurs 4 times: Q23:24, Q27:29, Q27:32, Q27:28.

مَلَإِيْهِ occurs 6 times : Q7:103, Q10:75, Q11:97, Q23:46, Q28:32, Q43:46

This single example already shows that perceiving *hamzä* spellings as traces of diachronic development of the Arabic language opens new perspectives for Qur'ān text analysis. The listing of locations reveals that the old, glottalized spellings occur in different *sūrä*'s than the deglottalized spellings with added corrective *hamzä*, which theoretically could lead to different datings.

IV. Amphibious *hamzä* in information technology

The position of this new *hamzä* in the form of a miniature head of *ʿayn* is analogous to that of the first generation vowel markers, i.e., the environment where it first emerged. First generation vowel markers shared a single, usually red, round shape positioned above, below or within the main script depending on its meaning /a/, /u/or /i/ (*one* shape, *three* positions, unlike modern vowel diacritics, which have *two* shapes and *two* positions, see Plate 1). Modern *hamzä* still follows this same archaic pattern: it occurs above, below or in line with the main script (see Plate 2). When a grapheme is positioned in line between skeleton elements, it can be called *amphibious*: in-between, to distinguish it from a diacritic that is placed above or below a main letter.

Of the three possible positions of *hamzä* the ones above or below the *rasm* or text skeleton are today encoded as composites consisting of a long vowel letter (*ʾalif, yā,ʾ wāw*) with an integrated miniature *hamzä*. This procedure does not acknowledge the historical threefold positioning of *hamzä*, but at least it produces workable results. However, the analogy with first generation vowel positioning means that standalone *hamzä* is, like archaic *ḍammä,* positioned within the script line, irrespective of the connections of the surrounding letters. Moreover, amphibious letters can occur with their own diacritics, e.g., مَسْئَلَة *masʾalä*, which would look unacceptable with superscript *hamzä*: مَسْأَلَة:

fig 15. Erroneous encoding concepts lead to stacking of amphibious characters

transcription	wrong: vertical alignment	correct: horizontal alignment
masʾalä	مَسْأَلَة	مَسْئَلَة

This behaviour is not explicitly covered by grammars of the Arabic language. Unicode, the modern industry standard for text encoding in the context of global computing, inherited this flaw in its definition of contextual character behaviour. All modern software and fonts are based on this standard and consequently do not handle amphibious letters, when they are written between two connected letters. As a result, with the present Unicode specifications for typographic behaviour, Contemporary Qurʾān Orthography can not be rendered on screen or printed without unpredictable non-standard adjustments. The reason is that Unicode defines the contextual behaviour

of 0621 ARABIC LETTER HAMZA as "non-joining"[9]. In practice, this only describes the behaviour of amphibious *hamzä* when it is positioned between two *non-joining* letters. The inline positioning between connected forms is supposed to be handled by a special superscript *hamzä* and the insertion of a supporting elongation bar, the so-called *taṭwīl*. This elongation, however, also known as *keşide* (Persian → Turkish) cannot be used for spelling of words in Arabic script, since it is subject to positioning constraints that vary from style to style and hence from typeface to typeface: a simple font change could literally pull the carpet from a word constructed in this manner.

The following table shows how two words that are grammatically identical and that need to be spelled analogously (*bad'a-n* and *šay'a-n*), cannot be handled correctly when amphibious *hamzä* is positioned between two *joining* letters. They share the same pattern $C^1aC^2C^3$ (where C^3 is a glottal stop).

fig 16. Non-joining in middle position:

transcription	accidentally correct presentation	correct
bad'a-n	بَدْءًا	بَدْءًا

fig 17. Joining in middle position:

transcription	structural misrepresentation	correct
šay'a-n Q2:48	شَيْءًا	شَيْئًا

Another very common case is amphibious *hamzä* in word-initial position, whenever a single-consonant word (*li, la, bi, ka,* etc.) is prefixed:

fig 18. Non-joining word-initial position:

transcription	accidentally correct presentation	correct
āyä Q2:106	ءَايَة	ءَايَة

9 Though the UNICODE standard assigns code point to ARABIC HAMZA ABOVE (U+0654) and ARABIC HAMZA BELOW (U+0654), these cannot be used unambiguously to encode amphibious *hamzä*.

This spelling with initial amphibious *hamzä* is not known in MSA, but it is a frequent feature of modern Qur'ān orthography. When a single-letter morpheme or the article is prefixed to it, it cannot be reproduced with modern editing or typesetting standards:

fig 19. Joining word-initial position:

transcription	structural misrepresentation	correct
la ʾāyä Q2:248	لَءَايَة	لَأَّيَة

The explanation is that MSA spelling rules out amphibious *hamzä* in initial position. Instead the *ʾalif-maddä* combination is used. It has been observed that even seasoned Western scholars don't recognize this spelling and consider it a typesetting or spelling error. They read, e.g., Q2:4 ٱلْأَّخِر *al-ʾāḫir* (with long /ā/) as if it were ٱلْأَخِر *al-ʾaḫir* (with erroneous short /a/), because they expect this long /ā/to be spelled with *lām-ʾalif-maddä* as ٱلْآخِر.

long /ā/ = ٱلْأَّخِر short /a/ = ٱلْأَخِر

The observed defect in the treatment of *hamzä* can no longer be corrected by generically changing the contextual behaviour of the Unicode 0621 ARABIC LETTER HAMZA, because the Arabic Block in Unicode is shared by all Arabic-scripted languages, some of which depend on non-joining *hamzä*. For instance in Persian there is a secondary, non-Arabic character that is indeed non-joining. Therefore it might even be necessary to introduce a new character ARABIC LETTER AMPHIBIOUS HAMZA in order to safeguard Classical Arabic Orthography and Contemporary Qur'ān Orthography in Unicode. An elegant alternative would be a language-dependent switch to change non-joining *hamzä* in a non-Arabic context and into amphibious *hamzä* in an Arabic context. This switch would not need to distinguish between Qur'ānic and modern Arabic. In Arabic proper, *hamzä* is always amphibious–though in MSA it is no longer used between continuous letters. In fact, the technical constraints introduced by computerized Arabic that are analysed in this essay made the use of prescribed amphibious *hamzä* impossible. As a result the spellings are rounded off to the nearest available characters, e.g., *šayʾa-n* شَيْـًٔا becomes شَيْـًٔا. However, for *la ʾāyä* لَءايَة there is simply no solution without the category of amphibious letters. As a result, integral treatment of the Qur'ān in CQO in a digital environment remains impossible.

V. Cautionary *maddä*

Modern grammars usually describe *maddä* as an orthographic device to avoid repetition of *ʾalif* when one *ʾalif* represents the glottal stop and one represents the long vowel /ā/, whatever the order. E.g. *ʾāḫir* is not written *ءاخِر but آخِر. However, in CQO the function of *maddä* is radically different than in MSA.

The first context is, when in CQO a glottal stop follows or preceeds a long vowel, the glottal stop is never written with an *ʾalif,* instead it is placed inline as an amphibious letter, unless surrounding vowels require a *hamzä on wāw* or *yāʾ* to be used. Therefore, unlike in MSA, theoretical sequences with double *ʾalif* involving the glottal stop, i.e., أأ or ءأ cannot occur in CQO. As a result, the *maddä* as rotated mini *ʾalif* does not exist in CQO. Instead, *maddä* is given a totally different task, here called *cautionary*, in two distinct contexts.

The first is when a long syllable is followed by a long, i.e., geminated consonant, e.g., أَتُحَاجُّونِّي *a-tu-ḥāǧ-ǧūn-nī,* with two instances marked: *āǧ-ǧ* and *ūn-n.*

fig 20. Cautionary *maddä* to mark doubly long syllable[10]:

transcription	CQO	MSA
a tuḥāǧǧūnnī Q6:70	أَتُحَاجُّونِّي	أَتُحَاجُّونِّي

The second context for cautionary *maddä* is when a long vowel, /ā/, /ī/ or /ū/ is followed by a glottal stop. In that case, irrespective of the spelling of the long vowel, and across word and sentence boundaries, a *maddä* is placed over it.

fig 21. Cautionary *maddä* to mark word-internal glottal stop after long vowel:

/āʾu/	*hāʾulāʾi* Q2:31	هَآؤُلَآءِ
/āʾi/	*qiṯṯāʾihā* Q2:61	قِثَّآئِهَا

10 Instead of "cautionary" this use could also be called ortho-epic.

/āʾu/	*buraʾāʾu* Q60:4	بُرَءَآؤُاْ
/īʾa/	*hanīʾa-n* Q4:4	هَنِيٓـَٔا
/īʾa/	*marīʾa-n* Q4:4	مَّرِيٓـًٔا
/ūʾu/	*sūʾu-n* Q3:124	سُوٓءُۢ

fig 22. Cautionary *maddä* to mark glottal stop across merged word boundaries:

/ā ʾa/	*yā ʾayyuhā* Q2:21	يَٰٓأَيُّهَا
/ā ʾu/	*yā ʾulī* Q2:179	يَٰٓأُوْلِى
/ā ʾi/	*yā ʾibrāhīmu* Q11:76	يَٰٓإِبۡرَٰهِيمُ
/ā ʾā/	*yā ʾādamu* Q7:19	يَٰٓـَٔادَمُ

fig 23. Cautionary *maddä* to mark glottal stop across independent word boundaries:

/ā ʾu/	*mā ʾunḏirû* Q18:56	مَآ أُنذِرُواْ
/ā ʾa/	*ʿalà ʾakṯarihim* Q36:7	عَلَىٰٓ أَكۡثَرِهِمۡ
/ī ʾa/	*fī ʾamrī* Q28:32	فِىٓ أَمۡرِى
/ī ʾa/	*yastaḥyī ʾan* Q2:26	يَسۡتَحۡىِۦٓ أَن
/ī ʾi/	*mawtihī ʾillā* Q34:14	مَوۡتِهِۦٓ إِلَّا
/ū ʾa/	*fa qālû ʾa nuʾminu* Q23:37	فَقَالُوٓاْ أَنُؤۡمِنُ

/ū ʾa/	*rabbuhū ʾaslim* Q2:131	رَبُّهُۥٓ أَسۡلِمۡ
/ū ʾa/	*takūnû ʾaqsamtum* Q14:44	تَكُونُوٓاْ أَقۡسَمۡتُم

Cairo orthography, or CQO, consequently and consistently uses *maddä* in this cautionary role.[11] To avoid confusion with spellings for glottal stop, a different spelling is adopted for the latter throughout.

11 There is one secondary function of *maddä* in CQO, namely to mark the so-called mysterious letters at the beginning of many sūrä's.

VI. Glottal stop before long vowels

The Cairo orthography tends to write glottal stop before long vowel without a chair, regardless the underlying sound change. In the case of glottal stop before /ā/, it is amphibious in all positions. Some examples:

fig 24. Amphibious *hamzä* for initial glottal stop before /ā/

example	CQO	MSA	operative sequence
ʾābāʾuhum Q2:170	ءَابَآؤُهُمْ	آبَاؤُهُمْ	*ʾā*
ʾādama Q2:31	ءَادَمَ	آدَمَ	*ʾā*

fig 25. Amphibious *hamzä* before /ā/ across morpheme boundary

example	CQO	MSA	operative sequence
li ʾābāʾihim Q18:5	لِأَبَآئِهِمْ	لِأَبَائِهِمْ	*ā*
yā ʾādamu Q7:19	يَٰٓـَٔادَمُ	يَاآدَمُ	*ā*
l-ʾāna Q4:18	ٱلْـَٰٔـَٰٔنَ	ٱلْآنَ	*ā*

fig 26. Amphibious *hamzä* for word-internal initial glottal stop before /ā/

example	CQO	MSA	operative sequence
l-qurʾānu Q2:185	ٱلْقُرْءَانُ	ٱلْقُرْآنُ	*ʾā*
ẓ-ẓamʾānu Q24:39	ٱلظَّمْـَٔانُ	ٱلظَّمْآنُ	*ʾā*
buraʾāʾu Q60:4	بُرَءَٰٓؤُاْ	بُرَآءُ	*ʾā*

In the case of glottal stop before /ū/, it is usually amphibious in non-initial-position. Some examples:

fig 27. Amphibious *hamzä* for word-internal initial glottal stop before /ū/

example	CQO	MSA	operative sequence
yaʾūduhu: Q2:55	يَـُٔودُهُۥ	يَؤُودُهُ	ʾū
masʾūla-n wa Q17:34	مَسْـُٔولًا وَ	مَسْؤُولًا وَ	ʾū
ṣ-ṣābiʾūna Q5:69	ٱلصَّـٰبِـُٔونَ	ٱلصَّابِئُونَ	ʾū
li yasūʾû Q17:7	لِيَسُـُٔوا۟	لِيَسُوءُوا	ʾū
yastanbiʾūnaka Q53:10	يَسْتَنۢبِـُٔونَكَ	يَسْتَنْبِئُونَكَ	ʾū
barīʾūna Q10:41	بَرِيـُٔونَ	بَرِيئُونَ	ʾī

In the case of glottal stop before /ī/, it is usually amphibious in non-initial-position. Some examples:

fig 28. Amphibious *hamzä* for word-internal initial glottal stop before /ī/

example	CQO	MSA	operative sequence
l-lāʾī Q33:4	ٱلَّـٰٓـِٔى	ٱللَّائِي	ʾī
muttakiʾīna Q38:51	مُتَّكِـِٔينَ	مُتَّكِئِينَ	ʾī
la ḫāṭiʾīna Q12:91	لَخَـٰطِـِٔينَ	لَخَاطِئِينَ	ʾī
ṣ-ṣābiʾīna Q2:62	ٱلصَّـٰبِـِٔينَ	ٱلصَّابِئِينَ	ʾī
ḫāsiʾīna Q2:65	خَـٰسِـِٔينَ	خَاسِئِينَ	ʾī

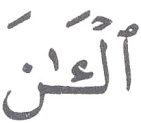
As can be observed in all these examples, the tight traditional letter blocks and the high density of superscript diacritics characteristic for later Qur'āns make amphibious characters very difficult to accomodate in pre-typographic *naskh* script.

VII. Amphibious letters in the calligraphic tradition

The contextual behaviour of amphibious *hamzä* in the calligraphic tradition is regular and straightforward: it is always placed between the preceding and following letter, where necessary over the middle of the connection[12] – even if the line is very short[13]. However, in the orthography expressed by pre-typographyc *naskh* script, amphibious *hamzä* was relatively rare. Clashes between spelling rules and script rules are theoretically impossible, as it is claimed that calligraphy is primarily cultivated to preserve the text of the Qur'ān.

The examples below show a number of instances where later Cairo orthography clashes with calligraphic rules in the treatment of final and non-final amphibious *hamzä* between connected letters. When reproducing the computerized graphemic content of the 1924 Cairo edition with computer-synthesized *naskh* script, a small number of unexpected results were encountered. The same spellings, when typeset with the 1924 metal typeface, designed especially for this Qur'ān, appeared not to be problematic. To understand the cause of the unexpected clashes, a comparison with other codices was made.

a. l-'āna



In verse Q4:18 of the Cairo edition, the word *l-'āna* is spelled with a cluster of four superscript graphemic attachments, [*sukūn*] [amphibious *hamzä*] [*fatḥä*] [amphibious *'alif*]. This cluster is the result of the spelling rule, characteristic of the Cairo edition, that glottal stop is written with amphibious *hamzä* when it is followed by long vowel.

ٱلْـَٔنَ ٱلْـَٔنَ ٱلْـَٔنَ Every grapheme of this word is present in Unicode,

12 This rules out the use of Unicode 0654 ARABIC HAMZA ABOVE because that character is designed to combine with the preceding letter.

13 In the typographic approach, but also sometimes in pre-typographic calligraphy, the connecting line is often lengthened to create more room for the amphibious *hamzä*. However, the lengthening of a connecting line, or *keşide*, is subject to calligraphic constraints that are usually respected by sophisticated typography. Moreover, some calligraphic styles (notably *ruqʿä*) and the typography emulating them do not elongate connecting lines. This fact rules out standardizing the use of Unicode 0654 ARABIC HAMZA ABOVE over the connecting element 0640 ARABIC TATWEEL. In other words, elongation of letters is not graphemic and therefore not available for orthographic purposes.

but the industry does not design Arabic fonts to handle such character sequences.

The rules of *naskh*, the style of choice for rendering Ottoman Qur'ān, do not allow elongation of *lām*[14], with the exception of a small number of well-defined cases. As a result computer-generated *naskh* built on this analysis produces a correctly shaped text skeleton, but with an ugly stack of attachments. Where the typographical writing of the 1924 Cairo edition uses a spacious skeleton base لـــس, the calligraphic constraints of *naskh* allow only a very tight connection لس that cannot accommodate the total of six superscript attachments of the second *letter block*[15]. Unlike the Cairo typography, in *naskh* calligraphy no elongation between initial *lām* and final *nūn* can be attested[16]. It must therefore considered to be ruled out.

Ottoman codices, use a different spelling for the word *l-'āna*, that does not conflict with calligraphic patterns[17].

14 In building this computer synthesis of traditional *naskh*, care was taken only to implement script-grammatical rules that were attested in manuscripts from a selected corpus of *naskh* calligraphy in the style of the Ottoman school.

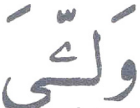
15 Letter block: in calligraphy, this is the smallest unit of writing. It consists of a single letter or an uninterrupted group of connecting letters. Script grammar of the specific calligraphy style determines the appropriate shape of a syntagm. The letter block is also the minimum unit of Arabic typography.

16 Only in one instance (Q10:51), Ruṣdi Efendi makes an exception to this apparent rule, to accommodate for the same spelling (with in minature the instruction *bi maddi-n wa tashīli-n* بمد وتسهيل):  , corresponding to Egyptian . The common elements are [A LN] الـ, the remainder of the graphemes, including *hamzä*, are superimposed on the basis of annotation systems that are not synchronised with the rules of the chosen script style.

17 *al-Qur'ān al-Karīm*, handwritten by the calligrapher al-Ḥāǧǧ Ḥāfiẓ Muḥammad Amīn Rušdī Afandi (for Turkish: Efendi), 1218/1803, reprint 1370/1951, Baghdad. This was one of the Ottoman codices of the corpus studied to develop the DecoType *naskh* simulator that led to the analysis presented in this essay.

b. walīyiya

The supplement of the 1924 edition contains a section about the use of miniature letters: they are inserted where "essential letters were missing in the *ʿUṯmānī* codices"[18]. It gives a number of examples, one of which happened to show irregular results when printed with computer-generated, regular *naskh*:



The word *walīyiya* "my protector" (Q7:196) consists of the elements *walīy* "protector" and the suffix *–ī(iya)*[19] "my". The skeleton consists of three letters: [WLY]. In miniature, a missing amphibious *yāʾ* is added including its own reduplication mark, *šaddä*, and its own subscript vowel i, *kasrä*: *walīy-iya*.

وَلِيِّيَ وَلِيِّيَ وَلِيِّيَ Every grapheme of this word is present in Unicode, there is even a code for elongation. Most font designers do not include the exclusively letters, like amphibious *yāʾ*. The unicode character is present in the data, but absent in the font, and by default printed as .

From such same text code, computer-synthesized, rule-based *naskh*– which is programmed to suppress illegal elongation[20] – generates a letter block [LY] لي that is too tight to accommodate the total of one amphibious, two superscript and two subscript attachments. By contrast, the 1924 Cairo edition is mechanically produced with a stretched skeleton base لـــي that breaks traditional script rules. But in this manner provides the necessary room to accomodate the big payload of graphemic attachments.

When comparing the same passage in other codices, variant spellings of such problematic words are encountered. These illustrate the different ways that calligraphers have solved the same problem.

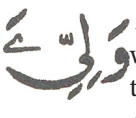
18 *al-Muṣḥaf aš-Šarīf*, Būlāq 1342/1924, page *yāʾ*. The name Osman or *ʿUṯmān* refers to the third caliph, who reportedly suppressed the proliferation of variant Qurʾāns.

19 The possessive pronominal suffix, 1st person singular *ī*, followed by a binding vowel a, c.f. *Grammatik des klassischen Arabisch*, Wolfdietrich Fischer, Wiesbaden 1972, §268, Anmerkung 2.

20 Incompatible elongation in fonts that emulate traditional styles is normalized or ignored by DecoType ace's Trashide® technology that drives this *naskh* model.

The 19th century masterpiece of Ottoman Calligraphy by Elhaç Hafiz Mehmed Emin Rüşdi Efendi[21] adds a second letter *yā'* to the main letter group: [WLYY]. In *naskh*, the curve preceding final *yā'* is a distinct letter: here it represents the penultimate form of medial *yā'*.

A recent Turkish Qur'ān in the Ottoman tradition[22] adds the correction to [WLY] in an unusual and subtle manner by placing a double point under the – swashed – final *yā'*. This is remarkable, because in Ottoman writing *yā'* never gets dots in final position. Therefore the dots are a clear hint at the missing *yā'* in middle position). Moreover, there are vowels for four consonants, while the skeleton contains only three : [WLY].



An Indian Qur'ān[23] solves this calligraphic conundrum elegantly within the calligraphic constraints. It should be noted that it adds the missing *yā'* in superscript final position instead of in the middle of the letter group.

A recent North African edition[24] also writes the missing *yā'* into the main text skeleton: [WLYY]. The resulting spelling does not conflict with calligraphic rules. Typical for North African writing, the extra inverted curve preceding final *yā'* is part of the same final *yā'*.

What makes this case interesting is that in terms of Arabic morpho-phonology, there is no letter missing. The elements *walīy* "protector" and the suffix *–ī*(*iya*)*/-ya* "my" contract into *walīya*, eliding one *yā'*[25]. The result is the text skeleton [WLY] that is seen in practically all quoted words. The annotational marks that superimpose the form *walīy-i-ya* with an extra syllable [WLYY]

21 *al-Qur'ān al-Karīm*, 1218/1803 reprint 1370/1951, Baghdad

22 *Kur'ân-ı Kerîm*, by the calligrapher Hamîd el-Âmidî, Istanbul 1973.

23 *The Holy Qur'ān, text, translation and commentary*, by Abdallah Yusuf Ali, Lahore 1934.

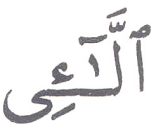
24 *al-Qur'ān al-Karīm*, *printed in the 'Uṯmānī skeleton text, following the reading of Imam Warš in the Moroccan-Tunisian-Algerian-African unified calligraphic style*, Dar al-Qur'ān wa l-Ḥadīṯ, Baghdad 1985

25 Since the word *walīy* ends in *y*, the suffix allomorph would be *-ya* not *-ī*(*iya*) according to W. Wright, *A Grammar of the Arabic Language*, Cambridge-Leiden 1896, paragraph 317.

cause problems with the computer-generated *naskh*. This in turn led to the discovery of variant spellings in other recensions.

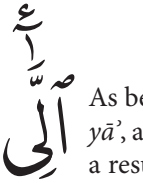
The 1924 Cairo edition is clearly based on a comparison with older manuscripts, possibly to correct spelling deviations seen in Ottoman Turkish codices. In this case the editors decided to return to the base form [WLY]. Without annotation marks, this *rasm* can be interpreted as a grammatically correct Arabic word meaning "my protector". It is intriguing why the editors inserted a complex correction (amphibious *yā'*, *šaddä, kasrä*), superimposing a grammatical form not recorded in standard grammars that is incompatible with the constraints of Persian and Ottoman calligraphy. One possible answer is that the skeleton text [WLY] reflects a version of the word, possibly *walīya*, that differs from the oral tradition which apparently has it as *walīyiya*.

c. l-lā'ī



The word *l-lā'ī* (Q33:4) also contains a letter block [LY] لـى that is even longer than the previous one. The long *ā* is not part of the *rasm*, instead it is written by a *fatḥä* on the *lām* followed by an amphibious *'alif* – which in turn is marked with a cautionary *maddä* preceding the *hamzä*. Since this *hamzä* is followed by a long vowel, in the Cairo spelling it must remain without a chair, i.e., amphibious, producing a sequence of two amphibious letters between two letters that calligraphy cannot stretched to accommodate them.

ٱلَّـٰٓـِٔى ٱلَّـٔـِى ٱلَّـٔـِى Again, all graphemes and supporting elongations of this word can be stored in the Unicode format, but no font can render them coherently.



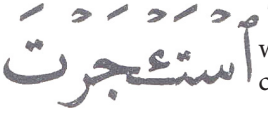
As before, *naskh* script grammar rules out stretched *lām* before final *yā'*, as it has not been attested in the inspected calligraphic corpus. As a result, the *naskh* computer synthesis again generates an ugly stack of attachments, because the industry erroneously defines all the characters as non-spacing, superscript diacritics.

Rüşdi Efendi, whose work belongs to the corpus used for this *naskh computer* model, typically uses a different spelling for long *ā*: a superscript miniature *ʾalif* followed by an *ʾalif* in the *rasm*. Simply put, the observed complication does not occur in manuscripts, because orthography and calligraphy used to be synchronized and fine-tuned to match.

The recent Turkish codex in the Ottoman tradition by Hamîd el-Âmidî has the same letter block as the Cairo edition, but without breaking calligraphic integrity. Graphemes are: a single superscript miniature *ʾalif* for *ā* and, characteristic for Ottoman orthography, subscript *ʾalif* for long *ī*. Note the inverted order of miniature *ʾalif* – cautionary *maddä*. In Ottoman orthography often no *waṣlä* is written on the initial *ʾalif*. Leaving it unmarked provides the same information as *waṣlä* in modern orthography.

The Indian edition uses essentially the same spelling as Hamîd el-Âmidî. Note that a *sukūn* is written over the consonantal element of the final long *ī*.

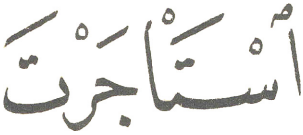
d. staʾjarta



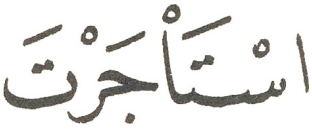
The word *staʾjarta* (Q28:26) contains a glottal stop, written with amphibious *hamzä*, typeset over an extra connection line.

ٱسْتَـٔـْجَرْتَ ٱسْتَـٔـْجَرْتَ ٱسْتَـٔـْجَرْتَ All graphemes and the extra connection line of this word can be stored in Unicode format, but no font can render them coherently.

Naskh rules preclude the extra connection line. Elongated letters before letters of the *ǧīm* class are never seen in Ottoman *naskh*. In pre-typographic scripts they are only seen in the most archaic variants, that had long died out in Ottoman times. The only exception to the rule of cascading connection exists in *thulth*-like styles. As a result, the amphibious *hamzä* with its own *sukūn* creates an unmanageable cluster of superscript marks in computer-generated *naskh*.

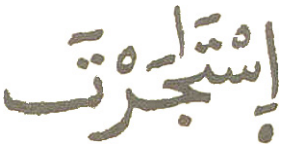


Again, Rüşdi Efendi follows a different spelling that circumnavigates the problem of the clustering superscript marks: he writes the glottal stop with an *ʾalif* (as pointed out above, historically the original function of *ʾalif*, before *hamzä* was introduced); the *sukūn* is rounded.



Hamîd el-Âmidî uses the exact same spelling as Rüşdi Efendi, but *waṣlä* is omitted.

The Indian edition uses the same spelling as Hamîd el-Âmidî. Note that the *sukūn* has approximately the same shape as in the Cairo edition.



The North African edition spells this word almost like the Cairo edition, but without breaking the rule of cascading *ǧīm* connection. Surprisingly, this recension writes the glottal stop as an amphibious *ʾalif*: this use of *ʾalif* – amphibious or superscript – is not known from Ottoman practice. *Sukūn* is omitted from this miniature *ʾalif*.

VIII. Conclusion

Ottoman calligraphy and Cairo orthography were developed from different perspectives as precision mechanisms to preserve the text of the Qur'ān with respect and integrity. Each of these systems consists of a subtle internal balance of rules, executed with total dedication and consistency.

Calligraphy and orthography are thus two distinct disciplines that create additional layers of precision on a meta-text level. But the underlying base text remains unaffected, while as such it stems from a different era and has its own structures. On top this *Urtext*, the Cairo orthographic mechanism meticulously fixes details that are not known from the earliest manuscripts, while the Ottoman calligraphic rule system is very different from that of the earliest used styles.

By creating a computer model of Ottoman *naskh* calligraphy and by applying it to render the Qur'ān in Cairo orthography, the author of this article discovered that these two meta-systems occasionally collide. In such cases orthographic precision takes precidence over calligraphic integrity.

It is suggested that the famous Ottoman calligrapher Aziz Efendi[26] was involved in typographic design work for the Cairo Qur'ān. The Cairo typeface clearly follows Ottoman *naskh* shapes and structures as much as possible. But it is also obvious that in last instance orthography and not calligraphy was the decisive criteria. One can only guess what it must have meant for the greatest Ottoman calligrapher of his time to be overruled by orthographic and typographic *Systemzwang*.

Note: All CQO examples were located with the Archigraphemic Koran Concordance, all MSA examples were computer-generated with Basis Technology's Arabic Editor–a reversible transcription system, the Ottoman *naskh* examples were computer-generated by ACE (DecoType's Arabic Calligraphic Engine), and the typesetting was done in WinSoft Tasmeem, a special version of Adobe InDesign that incorporates ACE and provides a sophisticated user interface. The author played a key role in the development of all these technologies.

26 Aziz Efendi: 1872-1934. His live and works are described in *Hattat Aziz Efendi*, Prof. Dr. Muhittin Serin, Istanbul 1999. This well-produced monography has a large number of beautiful reproductions which give a clear impression of his art. Nothing of Aziz Efendi's superb *naskh* ductus, the zenith of five centuries of Ottoman expertise, is reflected in the Fu'ād typography. What Aziz Efendi's role was in preparing the Cairo recension is not clear.

مَعَ ٱلشَّٰهِدِينَ ﴿٨٣﴾ وَمَا لَنَا لَا نُؤْمِنُ بِٱللَّهِ وَمَا جَآءَنَا مِنَ
ٱلْحَقِّ وَنَطْمَعُ أَن يُدْخِلَنَا رَبُّنَا مَعَ ٱلْقَوْمِ ٱلصَّٰلِحِينَ ﴿٨٤﴾
فَأَثَٰبَهُمُ ٱللَّهُ بِمَا قَالُوا۟ جَنَّٰتٍ تَجْرِى مِن تَحْتِهَا ٱلْأَنْهَٰرُ

Plate 1. Eighth to tenth century Qur'an folio without *hamzä, šaddä*, or *sukūn*. Both the script, with characteristic "sloping twins" (cf. Milo 2008 in *Schlaglichter*) and the shapes of the vowels are archaic. Only one vowel sign is used, a red dot. This single shape depending on its position above, below or inline indicates the vowel /a/, /i/ and /u/ respectively. Reduplication in any of these positions indicates the suffixed indefinite article {-n}. This is the precursor of modern *tanwīn*.This positioning pattern of a single shape with three positions survives in the later *hamzä* . Text in archigraphemic transliteration: ME A LSHD BN W MA LBA LA BW MN BA LLH W MA GA BA MN A LGQ W BTME A N BD GLBA R BBA ME A LFW M A LCLGBN FA BBHM A LLH BMA FLW A GBB BGR Y MN BGBHA A LA BHR. [see Milo 1989, in: Peter Führing, *Design into Art, Drawings for Architecture and Ornament*, the lodewijk houthakker collection,Volume II, plate 1073, Q5:83-85].

Plate 2. Tenth century Qur'an folio with *hamzä* shaped as truncated *ʿayn*, together with *šaddä*, but there is no *sukūn*. The shapes of the vowels are modern, the script is still archaic, with characteristic "sloping twins" (cf. Milo 2008 in *Schlaglichter*). Text in archigraphemes: FBLKM W MN A LD BN A SR KW A A D Y KBBR A W A N BCBR W A W BBFW A FA N D LK MN ER M A LA MW R W A D A GD A LLH MBBQ A LD BN A W BW A A LKBB LBBBBBH LLBS W LA BKBMW BH FBBD W H W R A THW R HM W A SBR W A BH BMBA [Bernard Quaritch Catalogue 1213, plate 15, Q3:186-187. With kind permission of Quaritch].