Iconicity as a Constitutive Parameter of the Anatolian Hieroglyphic Writing

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Introduction

The Anatolian hieroglyphic script was an autochthonous script invention, used minimally between ca. 1500–700 BCE[2] within different political states, firstly by the Bronze Age Hittite Empire, and subsequently by its Iron Age successor states in Anatolia and Northern Syria. With the exception of personal names and rare loan words, the script was exclusively used for the Luwian language, an Indo-European language of the now extinct Anatolian branch. The script can be described as a complex writing system, its individual signs functioning either as logograms or classifiers on a semantic level,or representing syllables on a phonetic one. To date, modern scholars have only paid very limited attention to the fact that the original scribes also explored the intrinsic iconic value of the script.[3] The current contribution owes much to long-term discussions with colleagues working on other writing systems, most notably with Andréas Stauder.

Iconic Representation

The iconicity of signs of writing can be described as the relationship between form and meaning of a sign. Not surprisingly, pictorial signs show a likeness to objects from the environment of the original users of the script. A meaning derived from a real-life referent inherently carries a level of decodable information to anyone familiar with the relevant cultural lexicon, for instance in the depiction of an animal or a tool. There are a number of Anatolian hieroglyphic signs that are not yet understood by modern scholars, because we do not fully grasp the sign's iconicity and/or the writing context in which it appears. It is conceivable that these sign shapes would have revealed their meaning to contemporary viewers because of their innate knowledge of the culture itself. While one might also consider whether we do not understand these signs because their representation works with a higher level of abstraction, this seems less likely on the basis of the very high number of understandable depictions; yet it cannot be fully excluded. If we thus assume that familiarity with the cultural context should be key to decoding the pictorial, what does this mean for access to written content without literacy?

For meaning derived from direct association, i.e. iconic representation, understanding is even possible without knowledge of the script as such, and can be achieved correctly by close interpretation of the depiction, although this may fail to reproduce the exact linguistic form that an original user of the script would have read. Ironically, the situation of the modern reader can be similar in that we may grasp a particular concept without being able to give it its correct Luwian name; especially, if the word in question is always written logographically. However, an iconic 'reading' has clear and severe limitations: it can only work for iconic-semantic writing, and fails already with semantic writing that is not iconic but, for instance, symbolic or homophonic. It cannot include phonetic readings unless the structure and derivation principles of the script are understood, which would not be the case for an illiterate onlooker. It is, of course, possible that an otherwise illiterate audience could have been familiar with a few signs

[1] Funded by the European Union (ERC-2022-COG, CAncAn, G.A. 101088363). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Council Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

[2] It was likely already used before but the exact date for the script invention is still disputed.

[3] Cf. e.g. MARAZZI 2016; PAYNE 2024a.

of writing, if they had specific relevance, yet likely only at the level of individual signs rather than longer textual phrases; much like young children may have learned the letters of their names without knowing the entire script or understanding these letters in different contexts. Thus, while a 'reading' of a hieroglyphic text on the basis of its iconicity might be possible for short, logographic sequences, it fails as soon as the writing context becomes more complex, i.e. through the use and combination of different types of signs, or other form-meaning relationships than iconic representation. Interestingly, if one considers the historical development of the writing system, the earliest writing that we can identify clearly as 'writing' (i.e. representing defined, repeatable linguistic content) consists of names and titles. While signs for titles tend to be semantic, it is the phonetically written names that (1) ensure we are truly dealing with 'writing', and (2) are not penetrable by means of interpretation.

Fig. 1: SİRKELİ 1

This epigraph to the relief figure of the Hittite Great King Muwatalli, Second part of the second millennium BCE (fig. 1; PAYNE 2015, p. 77) features among the earliest dateable hieroglyphic writing. It begins with four signs to the right of the king's shoulders, spelling his name syllabically: BOS.*MI-tà-li.*(fig. 2).[4]

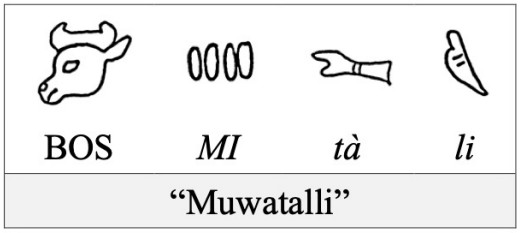


Fig. 2: Name Writing

For an illiterate viewer, this cannot easily be guessed. The association of the ox head with strength, Luwian *muwa-*, is already a leap, but the use of the second sign, *mi*, as a phonetic indicator to read the ox head *mu* and not *u*, as it would be read without this addition, is not accessible. Neither are the phonetic values of the following two signs, or the general structure of how this spelling of the name functions. While the rest of the epigraph consists of semantic signs only, one may still question whether a viewer (as opposed to a reader) would interpret any, and if so, how many, correctly. (fig. 3).

[4] Transcriptions follow LAROCHE 1960 completed by modern studies.

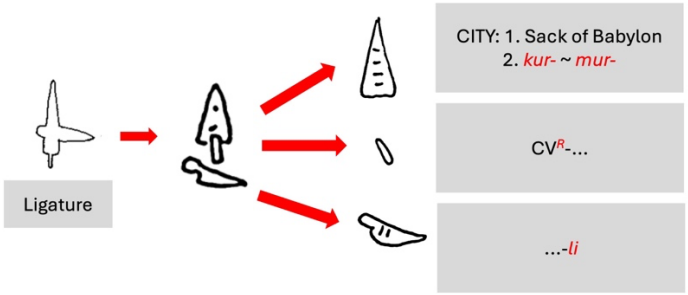
MAGNUS.REX	HEROS	*MURSILI*	MAGNUS.REX	HEROS	INFANS
hantawatturas	*hastallis*	*mursili*	*hantawatturas*	*hastallis*	*nimuwizzas*
"Great King,	hero,	(of) Mursili,	Great King,	hero,	the son"

Fig. 3: Titles

The association of the king's hat – the triangular shape with internal cross – with the king might be obvious to a person immersed in the cultural lexicon, yet whether the distinction "Great King" – adding the volute shape to this sign –, in contrast to lesser rulers was accessible, we cannot know.

The two-partite signs for "hero" and "son" are by no means easy to interpret: the sign "hero" is composed of a human face and a vessel. One possible way of deriving *hastall(i)*-, "hero" from this would if visualizing human (indicated by the face sign) bones in vessels, and associating the etymologically related word **has(t)*-, "bone", with *hastal(i)*-, "hero". Whether reference to bones was specific or merely a symbol of humans remains, in this context, is uncertain.[5] The interaction of the two elements in the sign SON have a logic that can be understood with knowledge of the script, namely MALE (IC-shape) + GIVEN (hand); the sign contrast with a similarly structured sign for daughter as FEMALE (pudenda) + GIVEN. Yet the iconicity of the MALE sign is far from obvious.

The sign for the royal name Mursili is a ligature of the city sign (URBS), with or without a vertical stroke, with a phonetic element /*li*/. On the basis of historical knowledge of the Hattusa dynasty the reading was never in doubt even if the exact connotations proved elusive. I would like to propose the following: the choice of the city sign is doubly motivated, firstly by association to the first Great King of this name, Mursili I, the conquerer of Babylon (THE CITY); secondly by phonetic association: while the Luwian word for "city", *gurta*-,[6] does not share the first syllable of the name Mursili, they do, in fact, rhyme. The semantic sign is followed by two phonetic ones, firstly the stroke +*ra*/*i* , which acts as an optional (cf. other spellings of the same name) phonetic classifier, reinforcing the first syllable of the name.[7] The final sign, *li*, writes the final syllable of the name, in accordance with standard practices of mixed semantic-phonetic spellings, but presumably also to disambiguate the name spelling from any writings of "city". (fig. 4.)



[5] There is some archaeological evidence for Hittite cremation vessels with bones, cf. AXELSSON 2017, p. 8.
[6] ZSOLT 2022: Hittite *gurta*- (eDiAna-ID 610). In: *eDiAna*. URL: http://www.ediana.gwi.uni-muenchen.de/dictionary.php?lemma=610 last visited on 09/07/2025.
[7] Cf. PAYNE 2024b. The fact that the sign +*ra*/*i* is optional in this name spelling confirms its status as a phonetic classifier.

Fig. 4: Writing of the name Mursili

In general, it is therefore important to stress the limits of illiterate decoding processes via understanding the referent depicted, and to distinguish this from literate, i.e. 'proper' reading. If we define reading as the decoding of fixed, repeatable linguistic sequences, the mere identification of individual symbols differs in that their meaning may be expressed in a variety of linguistic forms and is highly dependent on and thus changeable according to context. For instance, modern use of the pictogram of a standing person could indicate an exhortation to stand still, in the context of a pedestrian traffic light, or it could indicate a bathroom for men, if depicted on a door. In both instances, it is the context (traffic light vs. bathroom door) as much as its opposition to another pictogram (walking figure vs. skirted figure) which helps define the common meaning. In this example, the colour coding for the traffic light (green: GO; red: STOP) adds additional information, as does the position of the symbol (stop at the top, go at the bottom). Note, however, that the colour choice and position, as much as the symbol itself, are nothing but a cultural convention. Conversely, the bathroom symbols could be any colour, and often are, without anyone paying attention to it, as here, colour does not indicate meaning. It is also irrelevant which figure is positioned on the right or on the left. (fig. 5).

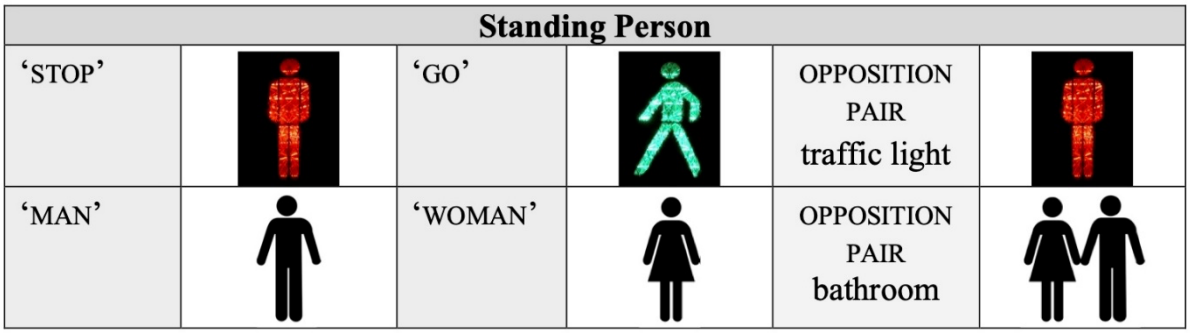


Fig. 5: Symbols in Context

Thus, iconic representation is accessible via viewing and contextualized interpretation of symbols, independent of any particular linguistic realization: e.g. the traffic light symbol could be expressed as "stop / stand / wait". Reading, on the other hand, depends on learned, repeatable one-to-one equations for signs. Because signs of writing can – but do not need to – have an iconic shape-meaning relationship, the boundary between the two is fuzzy.

In addition, the iconicity of writing may plausibly have served other needs both within writing as a system (discussed below), and outside of it, as a performative aspect of writing. While we do not have any texts which explicitly state this, it is more than plausible that the Anatolian Hieroglyphic script served as a means of identification for the original population. One would expect that it had a high status on several levels: as a native medium; as connected to the (Neo-)Hittite artistic tradition; as an original, local script invention; as a pictorial script (with possible knowledge of the existence and thus reference to Egyptian hieroglyphs); as a script used on impressive monuments; as a script used e.g. in cultic contexts. It is certainly possible to view Anatolian hieroglyphic writing as an expression of a shared cultural identity within its original context. Finally, it makes one further contribution to modern scholars outside of the reading-writing spectrum: it offers depictions of objects from an environment which may be compared to and contrasted with the archaeological record.

Signs Within a System

As shown above, symbols depend on context for their interpretation, and may be defined in pairs of contrast. While signs of writing have fixed value(s), which must be learned, their formation and motivation may likewise involve pairs (cf. above, the signs for SON and DAUGHTER) or groups of signs. For pictorial writing systems like Anatolian hieroglyphic, sign motivation is not just of interest for understanding the historical development of the script. Given that the script was an open system which tolerated additional and *ad hoc* new sign creations, the underlying principles must have been known to its scribes. If we today attempt to identify the governing rules of how signs were and could be designed, we not only gain new insight into individual form-meaning relationships but begin to see the fuller picture of the script's iconic scope, from ways of representation to concepts depicted, concerning the relationship of art and writing, and influence on the reader to name but a few.

To understand how Anatolian Hieroglyphic signs relate form and meaning, it is worth considering just how the iconicity functions. Following Stauder (2018), signs can be understood as representational in their iconicity, exhibiting a singular form-meaning relationship derived from an external visual referent, or relational in their iconicity, i.e. be accessible through knowledge of system-internal concerns, i.e. the relationship between different signs of writing. Representational iconicity lies at the heart of understanding the formation of pictorial writing, and it is this type of iconicity that has been best explored for the Anatolian Hieroglyphic script. As discussed already by Neumann,[8] the modes of depiction may vary, leading to different relationships between sign form and content. The most common relationships are, in Neumann's terminology: iconic, i.e. a horse representing a horse; figurative, or representation by semantic association, i.e. the king's hat representing the king, and homophonic, or representation by sound association, depicting semantically unrelated objects for their similarity of sound (fig. 6).

System-external **REPRESENTATIONAL ICONICITY**			
ICONIC	Form is likeness of intended meaning		Foot meaning "foot"
FIGURATIVE	Form shows something associated with intended meaning		King's hat meaning "king"
HOMOPHONIC	Form shows something of similar sound to intended meaning		Sphinx (Luw. *awiti-*) meaning "he came" (Luw. *awiti*)

Fig. 6: System-external Iconicity

Relational iconicity can be subdivided with Stauder into derivational iconicity, achieved through combination of signs and/or sign elements (ligatures; marking); and differential iconicity, in which signs form groups, the members of which can be understood by their diagnostic differences.[9] Access to such groups requires knowledge of the entire system of writing, as the diagnostic differences are not found in the relationship between sign and its real life referent but between conventionalized signs. Yet in pictorial writing systems, the relevant diagnostic differences may indeed look representational. Often, it requires a closer look to reveal that the origin of the sign shape, or parts thereof, lies in contrast with other signs of writing rather than (mere) representation of a single referent depicted. (fig. 7).

[8] NEUMANN 1992, pp. 29–31.
[9] STAUDER 2018, pp. 368–369.

System-internal **RELATIONAL ICONICITY**			
DERIVATIONAL – DIACRISIS	Form includes marking element(s)		Phonetic sign /*ia*/ (L210[9]): consists of sign /*i*/ (L209) with angled double bars indicating *a*-vocalization (diacrisis), derived from lips of sign *á* (L19).
DERIVATIONAL – COMPOUNDS	Form is compound of several signs		Two independent signs forming a semantic compound: volute (GREAT) + hat (KING) = "Great King"
DIFFERENTIAL	Form determined by relationship to other signs	vs.	The two signs on the left differ in the presence/absence of the head, which indicates consumption. Thus, the first sign reads "to drink" vs. "to libate", i.e. to offer a drink to a god. The difference becomes clear with knowledge of sign series, such "eat" vs. "drink".

Fig. 7: System-internal Iconicity

Examples for diacrisis contributing to instances of derivational iconicity include the use of two slanting bars to indicate that a phonetic sign should be vocalized with the vowel *a*. These two bars may themselves be an abbreviation of the sign L19, *á*, which represents a human face. The bars could, in origin, have been the face's lips. In contrast to compounding of two entire signs of writing, the use of double bars to indicate the signs vowel relies on extracting a single but distinctive feature of the sign, to be used as a diacritical marker. Another compounding strategy integrates one sign (reduced size) into another (full size). Examples include the sign L107, *mu*, which integrates four small strokes (as individual sign: L391, *mi*; here arguable used as phonetic indicator for the consonant *m*) into the sign L105, *u*. This type of annotation does not only happen on the phonetic level but also on the semantic: consider, e.g. the sign STELE (L267) which shows a small chisel, SCALPRUM (L268), within a building block, LAPIS (L267.8).[10] Given the general size sensitivity of the Anatolian Hieroglyphic script,[11] I would understand the integrated sign as a diacritical marker, and separate this type of complex sign from compounds which signal their joint reading through sign touching, but clearly show all signs as equal. One example would be the "Great King" hieroglyph in Fig. 3. (fig. 8).

[10] On such cult stelae, cf. CAMMAROSANO 2018.

[11] Not only are signs calibrated with respect to other signs, there are also interesting usages of superfluous vowels signs to mark the end of words, which are significantly reduced in size (e.g. word-final-*i* in the ASSUR letters).

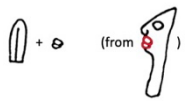
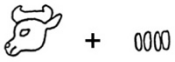
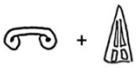
	PHONETIC ELEMENT	PHONETIC CLASSIFIER	SEMANTIC COMPOUND	
PARTS				
	i + *á*	cow + *MI*	Stone + Chisel	Great + King
COMPOUND SIGN				
	ia	*mu*	Stele	Great King

Fig. 8: Formation of Compound Signs

While relational iconicity, as we can find it within the script, suggests a completed state of script internal development, we should remember that the Anatolian Hieroglyphic script was at all times an open system which allowed for innovative use of existing signs, the reactivation of signs no longer commonly used and the formation of new signs.[12] In fact, representational and relational iconicity may – but need not – co-occur. It is clear that sign motivation by representational iconicity was an active principle throughout the history of the Anatolian Hieroglyphic script, thus leading to additional sign creations such as seen in late inscriptions; cf. e.g. the playful use of new phonetic signs in the TOPADA inscription.[13] Representational iconicity leads to visually meaningful units, when using established principles for form and meaning. Even *ad hoc* sign creations tend to be understandable, as long as scribe and reader adhere to a fixed set of rules regarding how visual referents are represented (e.g. directly, by semantic or homophonic association), and how sign values are derived (e.g. phonetic values by acrophony). Sign motivation by relational iconicity additionally depends on either a matrix sign with additional elements (diacritics; compounds) to derive further signs, or semantic groups, defined by visual likeness and contrast. In the case of existing sign groups, understanding a new member would likely be unproblematic but if a scribe were to devise a new group, it would be important that his readers understood which sign elements engaged in a relationship with other signs, and what particular meaning they carried.

Priming Effect

Decoding iconicity, furthermore, depends on the context provided both by common usage and by the respective literacy levels of the individual reader. A fluent reader will perceive contextual writing in a completely different manner to an inexperienced reader or a mere viewer. While less complex, one may cite the difference between a primary school child reading alphabetic writing letter by letter to a fluent adult reader skipping through a text but still digesting its content. A complex, pictorial writing system like Anatolian Hieroglyphic can additionally strengthen the reading process through priming effects: encoded in common usage (guiding the reader, facilitating the reading process), uncommon usage (obstructing the reader, creating emphasis), in the use of classifiers to trigger specific semantic lexica, and in the placement and use of specific signs to act as markers comparable to e.g. modern punctuation.

The following example (fig. 9) shows a sentence from a late tenth to early ninth century BC inscription from Karkamiš. The top line shows a simple drawing of the sentence, which may leave the uninitiated viewer or inexperienced reader with nothing more

[12] Cf. e.g. PAYNE 2019, p. 74 n. 23; p. 81; p. 94.
[13] Listed in HAWKINS 2000, pp. 460–461.

than the impression of coordinated, yet rather loosely arranged writing. Apart from the repetition of a few signs, and the possibility that the orientation of human and animal head signs might draw the focus to the left (in fact, this is the beginning of the line), there is not much that is obvious at the level of viewing the line of writing. A few signs occur repeatedly, yet without knowledge of the script, it is not possible to gain insight even into the structure, much less into the meaning of this passage. On the contrary, one might take the human and animal head signs as reference to humans and animals, which would not be correct here.

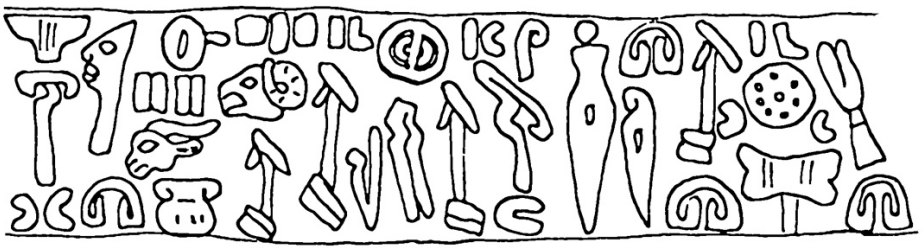
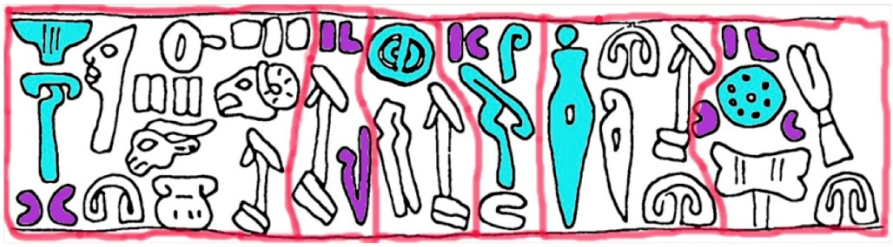


Fig. 9: KARKAMIŠ A11b+c, § 18a

The following (fig. 10) shows the same segment, separated into individual words. Additionally, semantic signs of writing have been marked in blue, and marking signs in purple. Their presence at neuralgic positions at the word beginning or end additionally serves to separate words for the fluent reader. Even without relating this to the transliteration and translation below, this annotation shows to what large extent the use of specific signs has a priming effect for the fluent reader, thus guiding the reading process. The separation into individual words becomes relatively easy: they always begin at the top of the register, and in this inscription typically with either a semantic sign (marked or unmarked), a marking sign or both. The end of a word is less frequently marked with a sign of writing but is mainly determined by its position at the lower end of the register. The annotated version now also reveals that there is a clearer order to the layout than may have been visible before: within the register, signs are placed in columns of 2–4 signs, depending on size, while accommodating the frequently non-geometrical shape of the signs. Both sign position as well as the use of specific signs serve to emphasize beginning and end of words. The use of classifiers in particular primes the reader for the semantic field of the word following it. This happens on two levels, both on semantic value and iconicity of the sign.



(“L350”)*á-sa-ha+ra/i-mi-sà-pa-wa/i-ma-za*	*|za-’*	DEUS-*ní-za*
asharimmis = a = ba = wa = mmanz	*za = ∅*	*massani = (a)nz*
n.pl.N qpt.	n.sg.N	d.pl.
the sacrifice and for them	this	gods

*|*CUM-*ni*	ANNUS-*sa-li-za-sa*	*|*(“PANIS”)*tú+ra/i-pi-sa*
anni	*ussallizza = s*	*turpi = s*
	n.sg.C	n.sg.C
with	annual	bread

“and the sacrifice for them (shall be) this: with the gods annual bread”

Fig. 10: Analysis of KARKAMIŠ A11b+c, § 18a

This extra-linguistic information performs multiple roles: an unassuming, at first glance rather loosely than strictly ordered series of signs in fact contains a significant amount of priming information which would guide the fluent reader – not just in terms of achieving efficient word separation –, thereby enabling their eyes to move sensibly through a textual passage. The semantic signs, meanwhile, prime the reader to activate the relevant lexicon. While this cannot be undertaken within the confines of this article, it would be worthwhile to study the numerical relationship of signs used primarily with their semantic value versus those used in a more even contribution with semantic or phonetic value versus dominantly phonetic signs.[14] Furthermore, it should be investigated whether priming positions correspond to specific iconic sign variants (e.g. monumental vs. cursive, internal decoration of signs), or whether there is a correlation between signs used and type of iconicity.

Results

The discussion above has shown that knowledge of the cultural environment contributes to decoding the iconicity of the Anatolian Hieroglyphic script. In turn, one should also question to what level knowledge of the script informs us about said environment. The distance in time to the original culture can be problematic for a modern analysis, due to loss of information. Nevertheless, some examples have shown that access to the pictorial is not homonymous with access to the meaning of writing. The script itself is a complex system that combines semantic and phonetic information, but furthermore, the iconicity of individual signs can also be shown to adhere to different, complicated patterns. Often, these can only be detected with knowledge of structurally similar examples from within the script. At the same time, there are instances where the pictoriality gives the modern reader some rough access even though exact connotations or the underlying linguistic term remain elusive.

[14] As the main (but possibly not only) derivation principle for phonetic sign values is that of acrophony, i.e. derivation of sound from the beginning of the word for the visual referent or whatever it is associated with, it must be assumed that absolutely all hieroglyphic signs had a semantic value, even if it is not attested in the surviving corpus. In turn, any semantic sign could lead to a derived phonetic value, yet in this direction the derivation is less obligatory; one might thus only speak of the phonetic potential in signs which are not attested with corresponding usage.

The historical development of the Anatolian Hieroglyphic script must be seen in its context as one of two scripts contemporaneously in use, within a cultural context that was – minimally in scribal circles – both literate and multi-lingual. This may be why the earliest distinct examples of hieroglyphic writing are neither purely semantic nor show a consistently easily interpretable iconicity.[15] In fact, many frequent semantic signs used in early epigraphs, i.e. for titles and genealogy, are complex sign ligatures which may or may not have been accessible to interpretation. Their analysis as presented above certainly relies on not only cultural context but also how other signs of writing behave. Historically, Anatolian Hieroglyphic writing emerges in the surviving record with phonetically written names, which are not readily accessible to interpretation. Moreover, the early, Bronze Age period already uses some difficult writing conventions such as phonetic classifiers, whereas some later periods see efforts to make writing more accessible through easier phonetic spelling, and semantic classifiers with simpler iconicity.

Iconicity has been shown to contribute to the script and to the reader/viewer on different levels and for different purposes. Its distinctive character, which relates it to (Neo-)Hittite art, may have served as one means of forming a cultural identity. The derivation of individual signs rests on varying strategies for drawing semantic content, i.e. in a system-external, representational manner on direct depiction, semantic or phonetic association. That multiple strategies are needed will be easily apparent since, for instance, abstract concepts defy direct depiction. Less obvious are system-internal conditions which arise from sign-to-sign relationships. Here, derivational and differential strategies can be determined as active principles.

Phonetic values, meanwhile, are derived by one main method, using the beginning of a (Hittite or Luwian) word as the phonetic value. Yet the use of phonetic signs can be complex both in sign compounds and as regards any specific sign's function within a written sequence. These aspects lead to a highly developed, complex system of iconicity. In turn, this is why access to meaning via form could only ever be a very limited phenomenon. Moreover, it is context dependent, and on its own not distinct enough to allow for a clear, single reading. Rather, it should be viewed as one element adding to the reading but not as the only one. In this aspect, the iconic character of writing shares some similarities with that of symbols. If one wished to take such a comparison further, position is likewise relevant within the Anatolian hieroglyphic script, but colour – as far as we know – did not play a role. However, it is worthwhile to bear in mind that the boundaries between iconic symbols and pictorial signs of writing are fuzzy, and that this intersection between picture and writing may have been playfully explored by the original scribes. The value in considering and differentiating sign iconicity lies in the potential for revealing formation practices which may give insight into semantic concepts. This further rejects any notion of pictorial writing as primarily visually interpretable.

The priming effect employs a strategy of redundant writing: the information given in the following in phonetic writing, is strengthened through the addition of semantic classifier, which serves to both mark the beginning of the word and to strengthen the communicated content while reducing information.[16] Iconically, it is important to note that the classifier sign commonly differs from the sign introducing the phonetic writing, despite the fact that in many instances it could have been repeated, i.e. used with its semantic value as a classifier and with its phonetic value to introduce phonetic writing. The fact that the normal strategy is to avoid such double interpretation of the same sign in sequence tells us something about the role of

[15] This is, however, partially also a matter of definition, as very early 'writing' that was purely pictorial and semantic is excluded from the definition of writing used above. However, no examples of siginificant length survive that could even be considered for such a category.

[16] LOTMAN 1990, p. 12.

visual difference between functionally different parts of writing. The very same strategy can also be noted in the use of phonetic classifier signs.[17]

To conclude, examining the iconicity of Anatolian Hieroglyphic inscriptions, individually, and of the script as a system, provides insight into interconnections with the contemporaneous (Neo-)Hittite environment, and, in particular, with its artistic traditions. At the same time, it shows that writing employed sophisticated strategies which not only went beyond a purely visual access to meaning but rather would have prevented 'reading' by interpretation. Proficient reading can only have taken place on the level of an educated, trained reader aware of not just sign forms and variants, but, furthermore, of derivational and organizing principles, i.e. of the spectrum within which the script operated.

[17] Cf. PAYNE 2024b.

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