“Are Writing Systems Intelligently Designed?” in *Early Writing and Agency in Archaeology*, edited by Joshua Engelhardt. Boulder: University Press of Colorado. (accepted for publication, May 2010).

Figure 1. Engraved bronze plaque from tomb 13 at Shizhaishan, Yunnan. (After Zhang Zengqi 1998 *Jinning Shizhaishan*, p. 260. Kunming: Yunnan Meishu Chubanshe.)

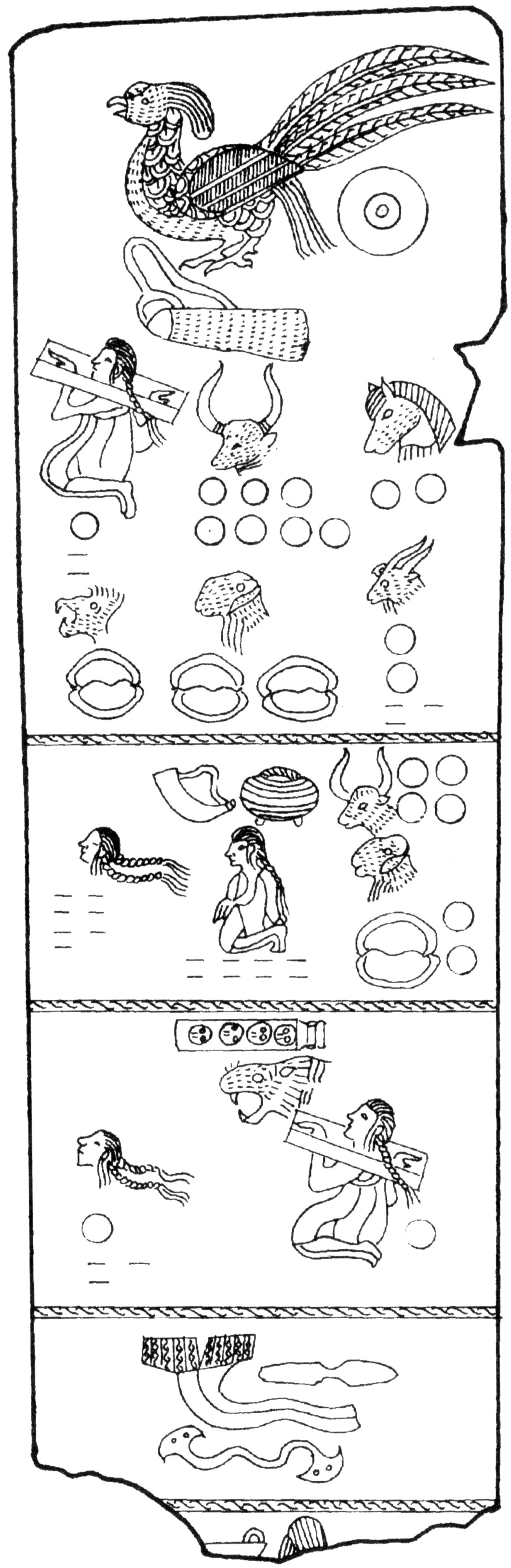


Figure 2. Replicating sign forms among engraved bronze items from the Shizhaishan cemetery. (After Zhang Zengqi 1998 *Jinning Shizhaishan*, pp. 28, 30, 31. Kunming: Yunnan Meishu Chubanshe.)

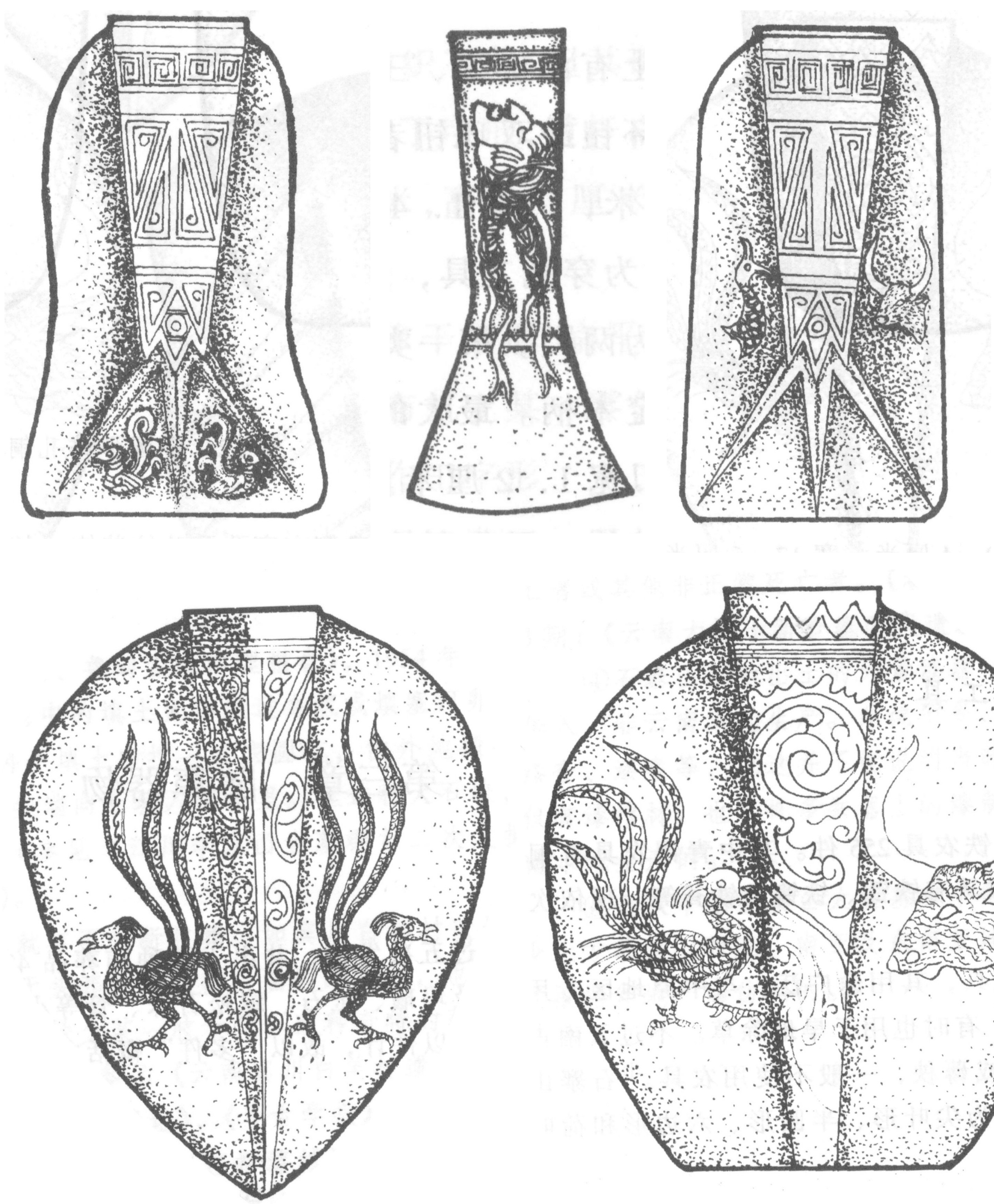
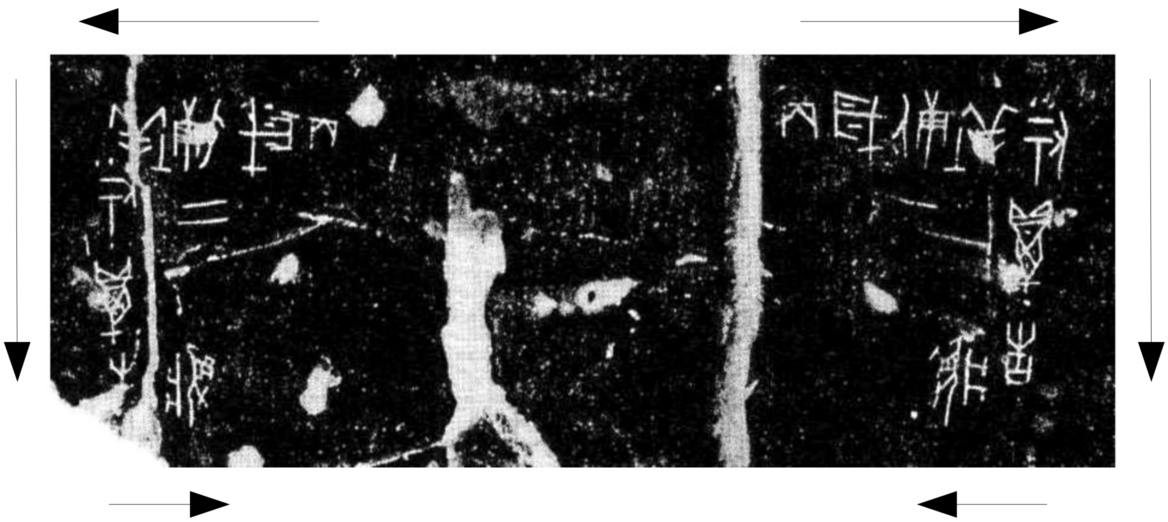
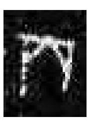
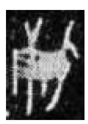
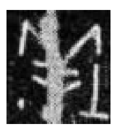
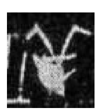
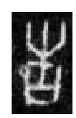


Figure 3. Two verbatim copies of the same divination text, showing variable script direction and concomitant boustrophedon mirror flips (graphs 2 and 8). Arrows indicate the direction of text. (After Zhongguo Shehuikexueyuan Kaogu Yanjiusuo 中國社會科學院考古研究所 2003 *Yinxu Huayuanzhuang dong di jiagu* 殷墟花園莊東地甲骨, p. 118. Kunming: Yunnan Renmin Chubanshe 雲南人民出版社.)



	1	2	3	4	5	6	7	8
LHS								
RHS								

Are Writing Systems Intelligently Designed?

Adam Smith

Columbia University, Society of Fellows

These English psychologists—what is it they want? We find them, voluntarily or involuntarily, ever engaged in the same work, – the work of pushing into the foreground the partie honteuse *of our inner world and of seeking for the really operative, really imperative and decisive factor in history just there, where the intellectual pride of man would least* wish *to find it (for example, in the* vis inertiae *of custom or in forgetfulness or in some blind and accidental hooking-together and mechanism of ideas or in something purely-passive, automatic, reflex-motion-like, molecular and thoroughly stupid).*

Friedrich Nietzsche, *On the Genealogy of Morals*

This paper concerns the genealogy of writing systems, not of morals. But, like Nietzsche's "English psychologists," I am interested in the role of "blind and accidental hooking-together and mechanism" in the formation of that genealogy, particularly to the extent that its results resemble the products of goal-directed human agency. In a manner perhaps somewhat contrary to the guiding spirit of this volume, I will suggest that the apparent design and efficacious functionality of writing systems are the product of less human agency and forethought than is generally imagined.

I approach the question of the origins of writing from the perspective of my primary area of interest, that of the early history of literacy and literate institutions in East Asia. Consequently, I will discuss primarily evidence from early China. However, the claims that I want to make are intended to be general ones, about the nature of emergent writing systems cross-culturally. I have also felt the need to touch upon results from recent work on the cognitive neuroscience of reading (particularly that of Stanislas Dehaene and colleagues, for which Dehaene [2009] is the most accessible point of entry), which has now reached a degree of informative sophistication that no one interested in the functioning of early scripts and their evolution can afford to overlook it.

The Origin of Writing as an Act of Creation?

The question of the origins of pristine scripts – those that appeared without borrowing from already literate neighboring populations – is a difficult one for several reasons. Since the transition to literacy typically takes place among a very restricted sub-population, only subsequently becoming more widespread, the earliest phases of script development are consistently the least well attested. The fact that the process of emergence seems to be relatively swift, taking place over a small number of generations, or perhaps in a single generation, compounds the problem of attestation. We typically lack direct evidence for crucial transitional stages. It is generally acknowledged, for instance, that the earliest attested writing from late second millennium China is likely to have been immediately preceded by some kind of developmental precursor (Bagley 2004; Qiu Xigui 2000:42-43). Direct evidence for it is frustratingly slight however, and for the time being confined to a handful of brush-written signs – uninterpretable but formally related to later sign forms – on ceramic vessels from the mid second millennium (Song Guoding 2003).

The emergence of literacy is also unconstrained by any technological or environmental prerequisites, the history of which might help us understand why pristine writing systems appeared when and where they did. There is no obvious technological barrier to the development of literacy in the many societies in which writing systems did not emerge. It doesn't require high temperatures, the extraction and processing of a specific raw material, high-speed rotary motion or complex tools. Indeed, its material prerequisites had long previously been fully explored in support of the human enthusiasm for pictorial representation and varieties of non-literate sign-use.

The relative swiftness of the transition to literacy, and its independence from technological or material constraints, have invited interpretations of the process that are distinctively articulated in terms of human agency and conscious foresight. Wang (2007:363), for instance, refers to the "individual genius … involved in [writing's] invention" and goes on to provide a sketch of a conscious, deliberate process (pp. 375-376). Boltz (1994:38-39) states that "writing is an invention…the result of a momentary occurrence. In this case, the moment was when someone realized that a graph or sign could stand for a … meaningful unit of language." Houston (2004:235) refers to a "moment of revelatory creation". Powell (1981:422) insists that cuneiform was invented by an individual.

The first scribes are often portrayed as tailoring their nascent scripts to the "needs of society" as they perceived them. Gong Yushu (2006:85) states that "social needs are the fundamental reason why [writing] is brought into being". Wang's (2007:iii) central aim is to consider writing from the perspective of "how the ideological and administrative needs of the early state were met." Cooper (2004:78) suggests that writing in China was "sparked by the organizational needs of a growing Shang polity." The implication in each case is that writing was invented by a first generation of scribes who were clear about their goals and designed writing systems to achieve them.

I will refer to the approaches just characterized as the "intelligent design" approach to the origin of literacy. The aim of this paper is not a simplistic overthrow of that understanding of script emergence, but rather to provide an alternative, perhaps partially parallel or complementary, account of the same phenomena that minimizes the role of foresightful human agency. There are, I suggest, several advantages to this alternative account. First of all, it provides a way around the methodological inaccessibility of an "individual genius" or "a moment of revelatory creation" in the archaeological or historical record, focusing instead on more tractable archaeological variables such as the intensification of production of sign-bearing objects, and the formation of communities of increasingly full-time specialists. Second, it accounts for several patterns of developmental change that characterize the early history of scripts which are puzzling from the point of view of the "intelligent design" model.

An Alternative Hypothesis: Begotten, not Created

The proposal to be presented in this chapter is that literacy emerges from precursor systems of non-literate sign-use that rely on more general and universal cognitive capacities for object recognition and naming. The transition is set in motion when a precursor system of sign-use is subject to repetitive intensification by an interacting community of specialist users, typically as part of more general trends towards intensification of production and full-time specialization in complex societies. Intensification in the use of a repertoire of precursor signs has two consequences. The first is its impact on sign users: it serves to train a more “word-like” and less “object-like” recognition of individual signs. Secondly, it greatly increases the population of sign exemplars and allows cumulative selectionist processes to operate on variation among those exemplars: variants that better support the visual recognition, memory and rapid lexical access required by nascent literacy replicate at the expense of those that do so less well. As a consequence, literate capacities of sign-users co-evolve with the sign repertoire: as the performances of sign-users incrementally approximate fully-fledged literacy, the system of signs that they use shed their original object-like visual properties and take on increasingly word-like characteristics. Signs change so that they stimulate their readers’ lexicons with less processing and less conscious attention, while readers’ visual pathways change to accelerate the passage from retina to lexicon. I claim that this happens by a fundamentally “blind” process of selection.

This transition, in which the performance of sign-users increasingly resembles fully-fledged literacy, and the repertoire of signs gradually shed their initial object-like traits, is still in progress during the earliest attested stages of several writing systems, including Chinese. By combining this evidence with examples of systems of non-literate sign-use, based on more general capacities for object recognition, we can get a good understanding of the nature of the transition, notwithstanding the generally poor attestation, alluded to above, of the hypothetical earliest stages of the major script families.

The hypothesized selectionist process is largely independent of any foresightful design goals on the part of individual users, and its long-term trends were probably largely opaque to them. It is only clearly visible by integrating the insights into patterns of long-term script change provided by palaeographic studies with perspectives derived from recent work on the cognitive neuroscience of reading. It is, nevertheless, the process responsible for granting visual signs the functional properties that allow us to characterize them as writing, namely the ability to stimulate automated, highly-specific, serial access to the lexicon, rapid enough to serve as linguistic input to the language areas of the brain in a comparable manner to more ancient aural pathways.

Visual Objects vs. Visual Words

Much of the psychology and neuroscience of visual perception has used experimental scenarios that involve the visual presentation of words or pictures of things to human subjects, for varying periods of time, with or without distractors or "primes" of various kinds, and measuring the effect of these variables on various tasks. Such tasks might include naming words or objects, or categorizing them semantically. Recent rapid growth in brain imaging techniques has allowed the cognitive models of how these tasks are performed to be more closely related to the cortical regions that are most active during their performance. (Dehaene et al. 2005 provides an accessible point of entry to this substantial literature.)

In some behavioral respects, subjects' response to visual (i.e. written) words and visual objects can be very similar: reading aloud a sequence of concrete nouns, and naming a sequence of images of their corresponding objects result in very similar oral performances. Indeed, there is good evidence that visual objects in an attended area of the visual field activate corresponding phonological representations without the subject naming them aloud, even when the subject is instructed to ignore them and to perform some other linguistic task (Morsella & Miozzo 2002; Navarette & Costa 2005).

According to the hypothesis presented here, this ability of visual objects to stimulate linguistic representations automatically is the "preadaptation" that supports the emergence of literacy. It also provides the first suggestion that there is a continuum from visual objects to visual words, one not marked by any sudden jump in the linguistic properties of the visual stimulus.[1]

There are important differences, however. For one thing, visual word recognition and naming (reading aloud) relies on a competence that is only about five-thousand years old, and in most human populations a lot less than that, while visual object recognition and naming have been around since humans acquired language. There are also a number of subtle but important behavioral asymmetries between visual object naming and the naming of visual words. One of the most informative for our purposes is the so-called Stroop effect (see MacLeod 1991 for an extensive review, on which the following summary is based).

The Stroop effect, in its most generalized form, refers to the fact that the task of naming visual words is essentially immune to the distracting effect of incongruent objects in the visual field, while on the other hand naming of objects is more subject to interference from incongruent visual words. The naming of an object may be inhibited (slowed) by the presence of a superimposed distractor word, but reading a word aloud is largely immune to distraction by objects. Word-distractors that belong to the same semantic category ("e.g. the word *ankle* on a picture of a hand," MacLeod 1991:167) distract the most. If the word is the same as the name of the object, it facilitates (speeds up) the naming of the object.

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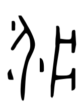
1 Note, for instance, that it undermines the suggestion of Boltz (1994:51) that a pictographic sign becomes writing at the "moment" when it changes "from being non-phonetic to phonetic." No such momentary change takes place: visual objects, including pictographic signs, are already capable of automatically activating phonological representations.

In a remarkable reversal of this pattern, “if a word is to be categorized [rather than named], then a picture of an object from another category causes a strong inhibition, whereas a word has no such effect on picture categorizing.” (Glaser & Glaser 1989:14) This shows that the Stroop effect is not due to anything as simple as the relative visual salience of words vis-à-vis objects. Rather, the asymmetry in naming words and objects suggests that visual words activate their corresponding lexical item (or its phonological form) in a more efficient, more automatic and less ignorable way than objects do. In some sense, the visual word follows a more streamlined, less easily disrupted path to phonology than the visual object. The question is why.

Several relevant factors have been proposed. Work has shown that Stroop-like asymmetries can be modified or reversed through repetitive training (Cohen, Dunbar & McClelland 1990; MacLeod 1991:181-182). This suggests that a visual entity may become cognitively less object-like and more word-like (vis-à-vis the Stroop effect), simply through association with its name in a repetitive task. Cohen and colleagues also suggested that word reading is a more “consistently mapped task... A particular sequence of letters is almost invariably associated with the word they represent,” whereas visual objects potentially have associations with a greater diversity of lexical items. In other words, a visual entity is more word-like if readers have been trained to associate it with a single lexical item, and more object-like if it has complex, context-dependent associations with multiple lexical items.

These proposals are directly relevant to the hypothesis being presented here. Intensification in the use of a set of object-like visual signs leads to habituating repetition, while the context of their routine use channels an association with a consistent referent. Visual objects that are members of the sign system become more word-like, from the point of view of the Stroop effect, than other categories of visual object.

The standardization of sign-forms that results from repetitive motor-habits of those who produce them under conditions of intensification greatly simplifies the visual processing required for recognition. Exemplars from the set of objects having a particular name can vary immensely in their visual appearance; individual exemplars can be recognized from a variety of orientations and under varying lighting conditions; color and surface texture may or may not make a difference to identity; objects are still recognizable when only a part is visible; etc. Pictographic (that is, object-like) signs, while remaining members of the class of visual object that they represent, capture and standardize salient visual features of an object or action, and present them in a standard orientation (table 1). The second consequence of intensified exposure to a repertoire of signs is that signs come to be recognized via the distinctive visual features of the *sign*, rather than of the *object* which the sign resembles and represents. Users' visual expectations about how a sign should appear are trained on the basis of previous exposure to signs, rather than visual associations with their referents. This initiates the the gradual wandering away from pictography that characterizes early attested stages of many scripts cross-culturally.

Table 1 – Visual objects (actions) or visual words? (Chinese script ca. 1250 BC)				
				
unwell	traverse	horse	deer	carry

The wandering away from pictography that occurs in the attested early developmental stages of scripts is not simply a process of increasing arbitrary abstraction. It is additionally characterized by the emergence of what I will refer to as a "componential substructure" that visually relates individual signs to one another. Understanding how and why this takes place, and how it contributes to the increasing efficiency with which signs stimulate robust and automated access to the lexicon, requires that we understand another important asymmetry between visual word recognition and visual object recognition. In this case the asymmetry is a neuro-anatomical one, one that has only very recently been clearly described: cortical regions active in processing visual objects and the visual words of modern scripts are distinct from one another.

The Visual Word Form Area

As early as 1892, the French neurologist Jules Déjerine proposed the existence of a region of the left cerebral hemisphere that housed a “visual memory center for words” (Dehaene 2009:54-60). His evidence came from two previously literate patients who became unable visually to recognize letters or words, despite being otherwise largely unimpaired linguistically and visually. The first was additionally unable to write, while the second could write spontaneously or to dictation, but not transcribe print into handwriting, or read his own writing after an interval of time. The second patient was able to identify letter forms by tracing them with his hand. He could also visually identify numerals. Déjerine associated these highly specific deficits with localized brain lesions found during post-mortem examination, suggesting that in the first patient the “visual memory center for words” had been entirely destroyed, and that in the second it had been cut off from sources of visual input.

In the last two decades a diverse array of clinical, behavioral and brain-imaging studies have led to dramatic progress in pinning down a specialized brain area of the kind hypothesized by Déjerine, in determining its precise location and internal structure, and in modeling its role in the reading of modern scripts (Dehaene 2009:61-119). Cohen and Dehaene (2004:466) located the region in “a precise sub-part of the left ventral occipitotemporal sulcus” (i.e. on the underside and towards the base of the “thumb” in the familiar “boxing-glove” sideways-on depiction of the brain), and coined the term Visual Word Form Area (VWFA) to refer to it.

The VWFA is adjacent to but distinct from other regions specializing in the recognition of other visual categories, including scenes, faces and objects (Dehaene 2009:72-74). Like these areas, the

VWFA receives input flowing forward from areas of the occipital lobe where more low-level visual processing takes place. Vinckier et al. (2007) demonstrated a posterior-to-anterior gradient of selectivity within the VWFA, in accordance with this more general hierarchical progression of areas within the visual stream. Exposing subjects to a graded series of stimuli from strings of low-frequency letters, via increasingly word-like forms, to words, they found activation becoming “more selective for higher-level stimuli [i.e. stimuli more like real words] toward the anterior” region of the VWFA. In other words, the VWFA initially identifies low-level visual building-blocks of word forms (letters in alphabetic scripts), before pooling those identifications to recognize mid-level structures which can in turn be compounded to distinguish individual words.

The relevance of this gradient of sensitivity to increasingly large visual sub-components of word forms to what was referred to above as the “emergent componential substructure” of developing writing systems should be apparent, and will be returned to subsequently. The hierarchical structure also neatly explains why, after the initial development of a core of graphic primitives, writing systems very rarely introduce unprecedented visual elements, preferring instead to evolve by morphing and recombining the conservatively-retained elements already represented in the VWFA hierarchy.

The cultural, acquired nature of literate competence implies that the VWFA is also acquired, by individuals as they learn a script (Dehaene 2009:204-207), but presumably also by populations as they develop a writing system. I suggest, and will attempt to illustrate below, that the accommodation of visual word forms to a VWFA developing intergenerationally within a population of script users is one of the major sources of selection pressure acting on synchronic variation within a script.

One final point should be made about the anatomical location of the VWFA: it is left-lateralized. This distinguishes it from other specialized higher visual areas, as well as from the lower-level visual areas of the brain, which are bilateral. Cohen & Dehaene (2004:473) suggest a number of reasons for this lateralization including “preferential connections to left-hemispheric language areas.” Here again we see an asymmetry between object-like and word-like visual stimuli, one which may contribute to the latter's ability to stimulate more rapid, more automatic and less easily distracted access to the lexicon.

The Shizhaishan plaque

In order to provide a concrete illustration of the kinds of object-naming behavior from which I am proposing fluent reading emerges over a course of centuries, I will resort to an artifact that does not belong to the cultures of any of the major script traditions, but which comes from a complex society that lay on the southwest periphery of the Han empire during the last centuries BC and the earliest centuries AD. The engraved bronze plaque illustrated in fig. 1 came from Tomb 13 at Shizhaishan 石寨山, location of the elaborately furnished burials of the elite members of that society (Yunnansheng Bowuguan 1959). The site is located approximately 40km south of Kunming, in Yunnan. The tomb dates to the Western Han period (206-25 BC), and is among the richest graves in the cemetery (Zhang Zengqi 1998:109-113). Although inscribed Han objects (coins, stamp seals and mirrors) appear in some of the burials, there is no evidence for the local production of texts in any language at that date.

***************** FIGURE 1 ABOUT HERE ******************

The engraved plaque from Tomb 13, however, is clearly a document, of either the ownership or transaction of livestock and humans. We are able to "read" much of the content of this document using the same pre-literate techniques of visual object recognition that its original owners would have used. The document is divided by horizontal lines into informational units, of which four are completely preserved and one only partially. The informational units appear to follow a consistent organization, with a heading or caption made up of a combination of depicted objects unique to that unit and centered at the top of the unit, followed beneath by representations of livestock items and accompanying numerical notation that recur across the first three units (Table 2).

The livestock items are all readily interpretable, thanks to both the pictographic realism of their representations and their repeated appearance in the many detailed sculptural depictions of elite life that appear on bronze objects from the Shizhaishan burials (see the line-drawings and color photographs in Zhang Zengqi 1998). Equestrianism and livestock herding were evidently major preoccupations for this group. So too was the enslavement and killing of other humans, which was also depicted extensively in the bronze models from the cemetery. The kneeling submission, severed heads and instruments of restraint that appear on the plaque have close visual parallels in the bronze sculpture, and presumably record counts of three categories of human victims and captives.

The numerical notation is almost certainly a base-10 system with separate signs for powers of ten (successively, a horizontal dash, a circle, and a more complex sign perhaps resembling a shell). Multiples of powers of ten are indicated by repetition of the signs.

The headings or captions are the most difficult (for us) to interpret precisely. The objects that make up the headings can be identified with varying degrees of confidence, but their inf

content is unclear. It seems likely, though, that they record the identity of individuals or groups, either donors or owners of the wealth recorded within the unit to which they correspond.

Table 2 – Shizhaishan plaque		
Unit	Heading	Item counts
1	pheasant + quiver + concentric rings	bound captives (12), oxen (70), horses (20), pigs (100), sheep (200), goats (23)
2	horn + basket (?)	heads (7), captives (8), oxen (40), sheep (120)
3	uncertain object + feline head	heads (13), bound captives (10)
4	uncertain objects	uncertain
5	container with handles + uncertain object	(broken)

We can only imagine the contexts in which documents like the Shizhaishan plaque may have been “read”, perhaps at funerals, or during other manifestations of social relationships or economic wealth. However, we can be confident that doing so did not involve a cognitively specialized form of lexical access – just plain, ordinary object recognition and naming. That is why we are able to extract most of the informational content from the document without resorting to any complex decipherment strategies. It is also why we would be able to sketch an approximate, but probably “readable”, reconstruction of most the original document based only on the contents of Table 2, without consulting the original a second time.

The arrangement of signs, although organized around some degree of spatial regularity, shows no evidence of an emerging script direction. There is certainly no evidence of emergent componential substructure to the sign forms, or of departures from pictographic representation. It requires no training to read, just an acquaintance with culturally-specific objects (and an ability to deal with numbers in the hundreds). It requires no feat of memorization to associate the signs (I count 23 distinct sign-types) with their referents, of the kind that would certainly have been required to handle the large sign-lists of the proto-cuneiform economic documents or the early Chinese divination records from Anyang, which are only transparently pictographic to a modest degree.

It seems unlikely that objects like this would have been produced in any substantial quantity or “read” with great frequency. The material is costly and the engraving technique effortful (although one should be open to the speculative possibility of comparable documents produced with other media and techniques). The visual complexity of the individual signs, and the likely context of use in relatively unusual commemorative events also argue against frequent production. Thus, not only is no training – in the sense of specialist education – required to read it, but the absence of highly repetitive and frequent handling of objects of this kind is unlikely to have trained – in the cognitive sense – a class of expert readers. It seems most unlikely that anyone associated with the Shizhaishan culture had a VWFA of the kind described above.

As far as we are aware, a writing system, and the practice of fluent reading, never evolved from this system of notation and the behavior associated with it. However – and this is why I selected this particular example for the purposes of illustration – we do see evidence for the beginnings of processes that might have channeled the behavior associated with the plaque gradually in the direction of literacy.

We have already drawn attention to the suggestion of Cohen, Dunbar & McClelland (1990) that "consistency of mapping" is one of the important determinants of the high degree automaticity that characterizes lexical response to word-like as opposed to object-like visual entities. Notice how consistency of mapping to words from visual objects appearing on the plaque is determined by the behavioral task of "reading" it. The structure of the document and its likely function limit the ways in which the visual objects appearing on it could be lexically realized.

Notice also that the depictions on the plaque already show signs of routinized replication. Not only do individual sign-types recur within the plaque itself (the numerals, ox, sheep, and the three human categories), but several of them appear elsewhere, incised or cast into other bronze objects from the Shizhaishan cemetery (fig. 2). The repetitive demands of the metalworker's task have already led to the selection of essentially arbitrary standardized forms for the depiction of the respective objects (the three-feathered tail of the strutting pheasant, the three-quarter view of the ox head, and so on).

**************** FIGURE 2 ABOUT HERE *******************

Repetitious Intensification

The replication of the Shizhaishan sign forms probably terminated with, if not before, the more general disappearance of most of the distinctive traditions of the Shizhaishan culture. But what incremental processes could, hypothetically, have elevated the repertoire of signs we see on the Shizhaishan plaque into a fully-fledged writing system? What incremental processes could have elevated similar, hypothetically precursor sign-repertoires into the early stages of writing that we do in fact find at, for example, Uruk around 3000 BC and at Anyang around 1250 BC?

I proposed above that the progressive emergence of literate competence, and of word-like signs, is the result of increasingly intensified performance, by a growing class of specialists, of the behavior involved in producing and "reading" object-like signs (such as those found on the Shizhaishan plaque), leading to the increased replication of the repertoire of sign forms. Amongst the most important progressive changes that characterize the growth of social complexity is the formation of collaborating groups of full-time specialists, often dependent to varying degrees on elite or institutional patronage at major centers of population. Organized, collaborative specialization can promote the intensification, standardization and elaboration of goods or services produced. It is important to emphasize that this applies not only to craft production – the manufacture of material objects which, for obvious reasons, is the primary focus of archaeological studies of specialization – but also to specialist activities of other kinds, including economic administration and ritual or religious performance. The association of a system of object-like signs with any sphere of activity that undergoes progressive specialization and intensification would support their increased replication, and increase their cognitive impact on a specialist class through repetitive and frequent exposure.

The cognitive consequences of "reading" or producing many different examples of documents like the Shizhaishan plaque on a daily basis, as opposed doing so only on special occasions, are considerable. Yet the behavior involved is, initially at least, only quantitatively and not qualitatively different. A gradient of intensification separates the two. As we have already suggested, the cognitive habituation brought about by repeated exposure to and production of object-like signs has several particularly obvious consequences. The first is an increased capacity on the part of specialists to memorize, for recognition and production, a larger sign repertoire, and a more complex set of documentary conventions. The second consequence of intensification of exposure is that signs come to be recognized via memory of the distinctive visual features of the *sign*, rather than of the *object* which the sign resembles and represents. Sign forms are liberated from their ties to object-like traits, and replicating lineages of signs are free to respond to selection pressures for more word-like features.

Although intensification of sign-using behavior by individuals is crucial for the cognitive training described in the previous paragraph to take place, a second important variable is the size of the community of sign users. Collaborating groups, integrated through institutional or elite patronage are, again, an important and distinctive feature of the socially complex centers of population with which nascent traditions of literacy are associated. Increasing the group size of collaborating sign-users enables increased replication, innovation and selection of signs, while maintaining the coherence of the sign repertoire and providing for its intergenerational transmission. Thus, I suggest that reconstructing the emergence of literacy in a particular cultural context requires that we look for evidence of candidate precursor activities that may potentially have incorporated sets of object-like signs, and which underwent sustained processes of intensification and group-oriented specialization.

The association between the beginnings of Mesopotamian literacy in the late fourth millennium and a single area of activity, economic bookkeeping, is well established. The Uruk cultural sphere is also the world region where we are best able to trace an evolutionary trajectory to literacy from behaviorally similar preliterate practices – from numerical signs on clay envelopes containing tokens, through numerical tablets, and "numero-ideographic tablets", to proto-cuneiform and its descendants (Englund 1998:48-56). More precise assessments than are currently available of progressive intensification and group-oriented specialization associated with the use of these technologies might better support the proposals being made here. Nevertheless, the broader contemporary picture of intensified local and long-distance exchange and disbursal of commodities (Algaze 2001) provides support of a more general kind.

The relative clarity of the Mesopotamian emergence of literacy makes it seem a compelling comparative model for filling in what are taken to be developmental missing links or gaps in attestation in other nascent traditions of writing. However, if the proposals put forth in this paper are correct, documenting the transaction of commodities is not the only activity that could support the evolution of literacy. Any behavior incorporating object-like signs that undergoes intensification in contexts of collaborative specialization can produce the same effects.

The earliest evidence for literacy in East Asia, in the last centuries of the second millennium BC, is overwhelmingly dominated, in numerical terms, by records of divination, almost all of which come from a single site near the modern city of Anyang (Keightley 1985, 1997). Several other textual genres appear in the centuries that follow, but it is not until the second half of the first millennium BC, almost a thousand years after the first appearance of the Chinese script, that the routine use of writing for economic administration is clearly in evidence. A number of scholars have expressed doubt that the maintenance of divination records could have provided sufficient motivation for the deliberate creation of a writing system, proposing instead that absence of early economic texts be attributed to the non-preservation of the organic materials on which they might have been written (Postgate et al. 1995; Bagley 2004). Bagley, for instance, is skeptical about whether keeping written records of divination could "supply a convincing motive for developing a lexicon of several thousand graphs." (p. 235).

In response, one might begin by noting that the early Chinese divination record *is* a fundamentally administrative genre, and that sustaining the incessant rounds of rituals to dead kin that divination was used to validate must have been a central economic preoccupation of the Shang kings at Anyang. In that sense, an association in the Chinese case between the earliest writing and the management of divinatory and ritual routines is perhaps already not such a poor match for the Mesopotamian model. However, one consequence of the hypothesis being put forward in this paper, that writing systems can arise from simpler precursor sign systems through intensification in their use undirected by the long-term intentional goals of their users, is that the need to find a plausible utilitarian pay-off for the efforts involved in designing and instituting a fully-fledged script is considerably lessened.

In fact, the history of divination in China shows precisely the trend towards intensification and collaborative specialization that I am arguing can drive the process of script-emergence. The practice of pyro-osteomancy – the heat-cracking of animal bones for the purpose of divination – is abundantly attested at widely dispersed sites in North China over the two millennia prior to the appearance of writing at Anyang (Flad 2008). This allows us to track changes in the practice over time with considerable precision. As Flad discusses, these include changes in the animal species used, increasingly elaborate preparation of the bones, and the greatly increased intensity with which the practice was pursued at later, larger sites capable of supporting workshops of collaborating full-time specialists. During the last centuries of the second millennium BC, there is a dramatic peaking in intensity of the practice, most notably at Anyang where it was supported by the patronage of the Shang royal family. At Anyang there is clear evidence of an unprecedented investment in divination, which was being performed (and documented in writing) literally on a daily basis by multiple teams of specialists (Smith 2008:148-54, 285-300). The rituals directed towards dead members of the Shang lineage, the scheduling and content of which it was the primary task of divination to inform, were similarly pursued according to an intense daily routine (Smith in press). Although the immediate precursors of Anyang writing remain unattested, and can only be speculatively reconstructed (Smith 2008:155-173), we nevertheless have a clear coincidence of repetitious intensification with nascent literacy.

Replication, Innovation and Selection

The discussion above of the selectionist process that I am proposing drives the initial emergence and subsequent development of literacy has been cast in fairly general terms. The aim of this and the following section is to use concrete examples drawn from early Chinese to illustrate the process and its evolutionary consequences. I have described how the initial break with sign-systems based on visual object recognition may have taken place, and how it permitted sign forms to drift, subject to a variety of selection pressures, away from object-like models and towards the accumulation of word-like traits. I aim to show that this process is ongoing within the early attested history of scripts.

Selectionist evolutionary processes of the kind that I am advocating require not just the replication of entities, but also the maintenance among them of variation on which selection can act(Boyd and Richerson 1988; Mesoudi, Whiten, and Laland 2006; Hull 2001:53-58; Szathmáry 2000; 2003). Competent scribes typically do not innovate when they produce sign forms. But there are two ways in which scribes can be thought of as introducing variation into a script. A scribe's motor performance in the execution of a sign may inadvertently – through the omission or modification of a stroke, a modest shift in position of a sign component, and so on – result in a form that would lie outside the range of their own expectation, and which might also push the envelope of received expectation of potential readers. Innovations of this kind may become fixed through habit in the practice of an individual scribe, and so be replicated sufficiently to influence the expectations of his or her readers. Innovations of this kind are typically slight. However, when we observe script change from a more macroscopic perspective of centuries, some of the changes we see – the gradualistic "morphing" of sign forms in particular – are probably due to accumulated and successfully replicating innovations of this kind.

A second source of introduced variation involves innovation by analogy. Phonological or semantic analogies between signs underlie the formation of inductive rules about how words should be phonologically or semantically notated. The forms in table 3, from the Chinese script ca. 1200 BC, show the analogical use of the FOOT[2] component for its semantic associations in writings for verbs of motion, with the FOOT sign inverted for "motion towards".

Table 3 – Verbs of motion written with the component FOOT 

2 I will refer to recurring pictographic signs or their components using names written in SMALL CAPS.

Regular Foot: “motion away”			
	zhī 之 “to go”	wàng 往 “to go”	zhú 逐 “to pursue”
Inverted Foot: “motion towards”			
	fù 復 “to return”	lái 來 “to come”	gé 格 “to arrive”

Innovation takes place when a scribe consciously or unconsciously, correctly or incorrectly, applies rules of this kind, instead of visual/motor memory of a received form, to produce a form that departs from the scribal community’s received expectation about how the word is written. The variation here is not the continuous “morphing” referred to above, but a discrete recombination of components.

Synchronic variation accrues through innovations of this kind. Galambos (2002) provides a visually and statistically compelling description of synchronic variation in the early Chinese script, concentrating on brush-written manuscripts from the middle of the first millennium BC and later. I draw on some of his data for the examples which follow.

Consider the following two forms from the earliest stage of Chinese (the second has already appeared in Table 3 above):

 腹 fù < pjuwk < $^{b/}$puk “belly; abdomen”

 復 fù < bjuwk < $^{b/}$buk “to return; go back”

The element common to the two sign forms is a phonetic speller Vessel, placed next to the belly of the Man sign in the first form, and above an inverted ("motion towards") Foot in the second.[3] Before the end of the second millennium, we already find the Foot being adopted as an additional component in writings for "belly", semantically unmotivated, but presumably an analogical innovation based on the phonetic and graphic proximity of the two signs.

For a later, mid first millennium BC corpus, Galambos (2002:201, 205-6) tabulates no fewer than nine non-trivial structural variants of this kind for "return", and 22 for "belly", all occurring in approximately contemporary copies of a single, intensively-reproduced set of text formulae. The original phonetic speller Vessel together with an inverted foot have become the stable core of all writing for both words. "Belly" with some reliability attracts the Meat 肉 component as part of a general analogical process towards writing names of body-parts with this element. "Return" tends to attract a number of additional elements associated with verbs of motion, including an extra uninverted Foot in addition to the original inverted one. There is also considerable evidence of the sets of writings for the two words interfering with one another; Meat sometimes gets transferred to "return" and the additional motion-verb elements sometimes get transferred to "belly".

There is, thus, considerable variation in Galambos's synchronic corpus for selection processes to act upon. As suggested above, readers constantly and largely subconsciously fine-tune their expectations about the appearance of visual word forms simply by being exposed to them. Variant visual word forms compete with one another for the mental resources of readers, and replicate depending on how successful they are in doing so.

The most frequent form for "belly" in Galambos's (2002:205) list, though it accounted for only 74/225 = 33% of tokens in the corpus, does in fact win the competition to become the standard form in

3 The phonetic speller, that I refer to for convenience as Vessel, is presumably a pictogram for 鍑 fù < pjuwH ~ pjuwk < $^{b/}$puk ~ $^{b/}$puks "wide-mouthed vessel", although I am not aware of any direct attestations of the pictogram in that sense.

received Chinese orthography (腹= Meat + Vessel + Foot). The overwhelmingly most common form for "return" (153/207 = 74%), however, is beaten by its third-place (14/207 = 7%) competitor (復), which differed from the former by the omission of a Foot.

The factors that determine the outcome of competitions of this kind probably include a mixture of the relative frequency of signs and their components, regularity with respect to analogical rules, the maintenance of lexical distinctions, the ease with which a sign form can be produced, and the degree to which a form can reinforce or modify the orthographic memory of a reader through its interaction with the structure of his or her Visual Word Form Area. Most importantly, there is little sense that "intelligent design" is directing the process towards a vision of how the writing system ought to function.

The Evolutionary Consequences of Selection

Here I outline three of the most obvious evolutionary effects of the processes of innovation and selection just described: 1. a decline in pictography, 2. the disappearance of the boustrophedon mirror flip in association with stabilization of script direction, and 3. the emergence of componential substructure.[4] All three have parallels in scripts other than Chinese. All can be seen as part of an ongoing gradual transition, spread over multiple generations, away from sign-use based on the cognitive capacity for visual object recognition.

1. Decline in pictography. Pristine scripts typically make extensive use of pictographic signs, the most obvious reflection of the cognitively object-like heritage. Chinese and cuneiform shed their pictography in a gradual process that is essentially complete by about five centuries after their first attestation (Nissen et al. 1993:119; Englund 1998:fig. 22). Egyptian hieratic does so on a similar time-scale, diverging from the hieroglyphic sign-list which is conservatively maintained for use in

4 For a more extended discussion, see Smith (2008:49-97).

monumental inscription (Loprieno 1994:17-18). The Maya sign-list appears to be distinctive in that it retains a pictographic aspect across the period of its attestation in all three attested media – monumental inscription in stone, painted texts on ceramics, and codices.

Table 4 – Declining pictography in Head			
date	c. 1200 BC	c. 800 BC	received orthography
graph form			首

2. Disappearance of the boustrophedon mirror flip. Scripts eventually settle on a standardized, linear, reading order. The reading direction of scripts associated with the recent emergence of literacy is, however, frequently neither standardized nor linear. The earliest Chinese inscriptions allow a single line of text to wander in any direction, and to change direction mid-sentence (fig. 3). This liberty is replaced by a standard top-to-bottom order in the space of two or three centuries. Egyptian hieratic is consistently right-to-left from the time of its first attestation (c. 2600 BC, five hundred years after the appearance of the script), while hieroglyphic inscriptions retain the earlier option of variable script direction (Loprieno 1994:18). The standard cuneiform reading order for the Ur III and Old Babylonian periods involves left-to-right sequences of signs within vertically ordered delimiting boxes or “cases”. The vertical columns of cases are present from the earliest proto-cuneiform precursors, but the arrangement of signs within cases shows only a rough tendency toward a linear arrangement at that early date (see also Johnson & Johnson, this volume). The fixing of a determinate script direction permits readers to acquire an efficient, deterministic and automated saccade strategy for rapidly

processing a sequence of signs.

******************** FIGURE 3 ABOUT HERE ********************

Of the scripts that show variable text direction, at least three – Chinese (fig. 3; Zhang Shichao 2002:110-119), Hieroglyphic Egyptian (Loprieno 1995:18) and early alphabetic Greek (Jeffrey 1961:43-50) – show a left-to-right mirror-image reversal of sign forms (the boustrophedon mirror-flip) correlating with changes of script direction. As variable script direction is eliminated to support a simplified saccade strategy, mirror-image variants also disappear. This again represents a paring-away of traits associated with visual object recognition. The visual identity of objects is typically preserved under a left-to-right mirror-flip, but not that of visual words in developed scripts.

Significantly, from the point of view of the cognitive foundations of nascent literacy, a comparable pattern of reversal, for a variety of modern scripts including English, Chinese and Japanese, has been noted in early attempts at writing by young children and in certain reading-impaired patients (Gottfried et al. 2003; Schott 2007; Wang et al. 1995; Wang et al. 1998). Dehaene *et al*. (2005:339) interpret these phenomena in the following terms.

> A principle of mirror generalization seems to have been deeply entrenched by evolution into our visual system, presumably because the identity of most objects in the natural world remains the same under a mirror-image transformation. After exposure to a single image in a fixed orientation, humans and many animals spontaneously treat the mirror-symmetrical version as identical to the original. Furthermore, inferotemporal neurons frequently respond identically to mirror-image pairs of objects, even if they have been trained with only one view. (*loc. cit.*)

> [Mirror-writing phenomena fit] with a selectionist hypothesis according to which learning to read proceeds by minimal reconfiguration of a pre-existing architecture evolved for object recognition, and which initially incorporates a principle of mirror-image generalization. (*loc. cit.*)

The same authors also remark upon the similarity of these clinical and developmental manifestations to the ancient script phenomena discussed here.

3. Emergence of componential substructure. This final pattern of development is in many ways the most important. I suggest that it directly reflects the gradual appearance of the hierarchical structure of the Visual Word Form Area discussed above. Systems of object-like signs, such as those occurring on the Shizhaishan plaque, show little evidence of the compounding of signs with single lexical referents.

The most obvious and most often discussed source of componentiality involves the reuse of simple signs in compounds to provide phonological or semantic cues. The writings for "belly" and "return" discussed previously are examples of compound signs from the earliest attested stage of Chinese, each with two sub-elements. We have already described how they illustrate a more general tendency for sign-forms to attract additional components. In Galambos's (2002:201-207) list of their mid first-millennium descendants, with the exception of a single form with two components used to write both 1.4% instances of "return" and 1.8% of "belly", all other variants have three or more components. The most frequent (74%) form for "return" has four, and the most complex (2.4%) has five.

A second progressive development of componential structure happens on a different level, below that of the structural components just discussed. It arises by what I referred to above as gradual "morphing" rather than structural rearrangement through analogical innovation. It manifests itself as the emergence of a discrete and standardized repertoire of simple, often semantically and phonologically unmotivated components that form the fundamental building blocks from which all signs in the sign-list come to be built. This is intimately linked with the progressive decline in pictography described above. Individual signs at an early stage in this decline are typically composed of the flexible contours required for recognition of the sign as a depiction of an object. These are gradually replaced by discrete and repetitive elements drawn from a limited repertoire of abstract strokes. However, the process continues well beyond the limits of pictographic decline, as long as visual word forms are free to evolve away from the anchor of a conservative model.

The progress of the HEAD sign in table 4 illustrates the process. The outcome is a word form constructed from a set of visual elements that are recycled in many other signs in the script. The HEAD sign has been brought into an overlapping geometrical alignment with the dots, boxes, horizontals and intermediate-level structures of other signs in the received orthography like 百, 自, 前, 羊, 頁 and others. None of this recurring componential substructure has any phonological or semantic link with HEAD. Although the recycling of visual elements is immediately apparent on inspection, to readers and non-readers of the script, it is not consciously attended to in any way while reading is taking place. Nevertheless, like the alphabetic componentiality of visual words in other modern scripts, it is likely that it makes a contribution to the fluent rapidity with which signs stimulate lexical items during reading, operating through the efficient hierarchical structure of the Visual Word Form Area with which it has co-evolved over millennia of Chinese literate history.

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