

# Interpreting Textual Artefacts: Cognitive Insights into Expert Practices

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## Abstract

Ancient textual artefacts are the substrate of our scholarly knowledge of ancient civilisations. This knowledge is discovered, extracted, and created through the daily practice of interpretation of these ancient documents. The cognitive aspects of this act of knowledge creation are at the core of the research presented in this paper. In order to identify the various cognitive processes that are mobilised to extract meaning from ancient and difficult to read textual artefacts, I have observed how papyrologists approach the task of interpreting Roman stylus tablets and how Assyriologists study tablets written in an as-yet-undeciphered script, Proto-Elamite. Linking these observations with findings from the cognitive sciences, I have identified perceptual processes that establish a visual feedback loop, a kinaesthetic feedback loop, and an aural feedback loop. These feedback loops only become effective sense-making mechanisms if they integrate processes that allow for knowledge to grow. These processes are conceptual processes that involve semantic memory, structural knowledge as well as insight, creativity and collaboration.

# Interpreting Textual Artefacts: Cognitive Insights into Expert Practices

by Ségolène Tarte

## 1. Introduction

Ancient textual artefacts, as individual objects and as corpora, are the substrate of our scholarly knowledge of ancient civilisations. This knowledge is discovered, extracted, and created through the daily practice of interpretation of these ancient documents. Digital tools developed to support scholars in their endeavour often take an approach whereby the aim is to automate aspects of the task. In an effort to further support experts in the act of interpretation of ancient documents, rather than directly try to decipher and interpret the textual artefacts themselves, the focus of this research is set on the scholars themselves. The subjects of the enquiry presented in this paper are the scholars who make sense of the textual artefacts, rather than the task they engage in. Ultimately, once an understanding of how experts interpret ancient textual artefacts is gained, software tools that support the experts in the process of the act of interpretation can complement the digital tools that automate aspects of the interpretation (e.g. OCR software). This paper therefore explores the cognitive aspects of knowledge creation and meaning extraction. In contrast with cognitive archaeology, where the endeavour aims to understand the minds of the ancient people, the cognitive approach adopted here sets out to understand the minds of contemporary people.

In the first section I introduce the textual artefacts themselves, presenting their main characteristics and summarising briefly the state of current knowledge about them. A short overview of two models of the act of interpretation in papyrology and palaeography are also presented. I then turn my attention to the expert practices of those setting out to interpret these textual artefacts and present some of the cognitive processes that I have identified through an ethnographic study of papyrologists and assyriologists in their scholarly endeavours. These cognitive processes, identified through direct observation, are each illustrated and further linked with reports from studies in the cognitive sciences that have investigated the nature of similar phenomena in the controlled settings of laboratory experiments or as specific case studies.

## 2. Textual Artefacts and their Interpretation

The types of ancient textual artefacts under the scrutiny of experts for this research are typically difficult objects to read and interpret. I have chosen to concentrate on scholars interpreting Roman stylus tablets and Proto-Elamite clay tablets as these artefacts present some commonality as well as some differences, notably that the language used for Roman tablets, Latin, is well known and understood, whereas Proto-Elamite, the script found on the eponymous tablets is yet to be deciphered. In this section I describe these textual artefacts, giving some background and highlighting some of the difficulties in interpreting them, before I review and discuss briefly the existing models of the act of interpretation as they have been devised for papyrology and palaeography.

### 2.1. Roman Stylus Tablets

Roman stylus tablets (Figure 1A), also called wax tablets, are the best known type of wooden tablets used for writing in the Roman world. Their study falls into the remit of papyrology. These tablets are made of wood and their centres have been hollowed to be filled with a coat of beeswax. The writing was inscribed in this layer of wax with the pointed-end of a stylus made of bone, wood, or metal (Bülow-Jacobsen, 2009). The layer of wax also allowed for erasure, by smoothing the wax with the spatula-shaped end of the stylus, and for reuse, by renewing the layer of wax. Their typical intact size is approximately 12cm x 7cm, and the writing normally runs left to right in the direction of the longest edge of the tablet. Some tablets were double-sided, hollowed, wax-filled and inscribed on both sides. A number of tablets could be bound together with strings through two holes drilled in the thick border of the tablet along its long edge, letting the text cover more than one “page”, on diptychs and triptychs. Such multi-“pages” documents could be further sealed and signed.

Some two hundred such tablets were found at the military fort of Vindolanda, near Hadrian’s wall in the north of England, during successive archaeological excavations (conducted between 1973 and 2003), alongside numerous ink-on-wood leaf tablets, spanning a period between the middle of the first and the middle of the second centuries AD (Bowman and Tomlin, 2005). All of these writing tablets are usually found in refuse ditches, sometimes half burnt, and more often than not, damaged and fragmentary, surrounded by “a wide variety of organic remains and artefacts” (Bowman, 1994, p8). With some notable exceptions (e.g. Vindolanda Tablets Online,

2003, Exhibition/Documents/Writing tablets - forms and technology), the wax of the writing tablets has perished, so that all that remains of the ancient writing are the scratches that the tip of the stylus might have left on the wood through the wax.

As the scratches left in the wood beyond the wax are more a side product of the writings than their primary aim, these scratches have varying degrees of depths (in the sub-millimetre and millimetre range), when they are at all present. The condition of the artefacts also affects the legibility of their text. They are often fragmentary and incomplete, and the text is often obscured by stains and damage. The pronounced character of the woodgrain of the tablets, probably accentuated by their underground sojourn, also impedes greatly the legibility of the scratches, turning the reading and transcription tasks into a 3D problem (that bears some similarities with epigraphy), rather than the more common 2D problem presented by contemporaneous ink on papyri or leaf tablets. Palimpsests can further occur; when portions of text are erased and rewritten, the two versions of the early and amended texts leave superimposed scratches in the wood. Additionally, the writing itself, Latin cursive, can present both palaeographical challenges and grammatical and orthographic stumble blocks. These tablets are usually documentary rather than literary: “Most surviving stylus tablets are business and legal documents, accounts, contracts, affidavits, and receipts, although they could be used for school exercises and letters” (Vindolanda Tablets Online, 2003, Exhibition/Documents/The use and formats of writing tablets). So the Latin in use in these texts is closer to a spoken Latin than to the Latin transmitted to us by literary sources. These tablets being records of official business however often implies the use of formulaic language, whether fixed or not by the power in place, and thus brings experts to expect finding dates and places in the text, as well as names and possibly professions of those signing the document as part-takers and witnesses of the recorded transaction. Finally, direct access to the textual artefacts is often limited, so that scholars make use of digital avatars of the documents (in the form of digital images) to conduct their investigations.

**Figure 1: Examples of ancient textual artefacts.**

(A) Vindolanda tablet 974; dimensions: approx. 12x8 cm. Held at the British Museum, London. Source: Vindolanda Tablets Online, 2003.<sup>1</sup>



(B) Proto-Elamite clay tablet P008010 (CDLI number); dimensions: 5.9x5.9x1.6 cm. Held in the Louvre, Paris. (Museum number: Sb15081). Source: Cuneiform Digital Library Initiative, 2013.<sup>2</sup>



## 2.2. Proto-Elamite Clay Tablets

Proto-Elamite tablets (Figure 1B) are clay tablets originating from Ancient Persia and dating to 3100-2800 BC. Their study falls into the remit of Assyriology. These tablets are made of quadrangular cushion-shaped clay and the texts consist of impressions made, probably with a rounded-tip reed stylus, in the soft wet clay. The clay was then sun-dried, rather than fired like pottery; this allowed for reuse by simply re-humidifying and remodelling the clay. Their intact sizes varied from 21cm x 26cm with a thickness of 2cm for the largest known tablet to much smaller palm-of-the-hand-sized cushions. The direction of reading of the script is uncertain, however if columns are taken as references then the script runs from top to bottom starting in the top left corner (and if lines are taken as references, the script runs from right to left starting in the top right corner); the text could be continued on the edges of the tablet and on its reverse.

The entire corpus of Proto-Elamite tablets today consists of a little over 1600 artefacts including complete tablets and fragments. Most of the finds were unearthed at Susa, in today's southwestern Iran, during successive excavation campaigns that took place between 1884 and 1979. Being unfired (unless by accident through the burning of buildings), these clay tablets are very brittle and thus often fragmentary. The script they bear has, to date, only been found on clay tablets (i.e. no stone inscriptions or on other support have been found).

"Proto-Elamite is a derived writing system originating from the Uruk invention of writing in southern Mesopotamia during the middle of the 4th millennium BC. Scribes in Susa in southwestern Iran took over a majority of the numerical signs as well as many of the numerical systems from the older proto-cuneiform system" (Cuneiform Digital Library Initiative, 2013). Although the script is to-date undeciphered, the current knowledge around these tablets is far from nil. They are administrative accountancy documents with a formulaic layout and a well-known semantic structure. The first entry, the heading, identifies the person or institution the accounts belong to; then comes an in-line list of entries (as opposed to a tabulated list) where each entry starts with a logographic notation describing people and objects followed by a numerical notation (the numerical systems are loaned from proto-cuneiform, hence understood); and finally, the last entry is a total, made of a collective logographic notation and the sum of the preceding numerical notations (Englund, 2004). The layout is also fixed; once the obverse is full, if the list is incomplete it is continued on the reverse by turning the tablet along the direction of writing. The last entry is also inscribed on the reverse of the tablet, but by turning it around an axis perpendicular to the direction of writing (so running in the opposite

direction of the continuation of the list). A seal impression can also figure on these tablets, on the reverse, between the end of the list and the total. An indexed list of the symbols encountered on Proto-Elamite tablets is continually updated, and currently counts over 1700 symbols, some of which are grouped based on their assumed semantic connection. The writing system is mostly logographic, but person names seem to use the script in a syllabic way. The challenges presented by these textual artefacts are thus multifarious. Access to the artefacts is often limited (whether by their geographical location, or by their state of conservation) so that scholars often make use of digital avatars of the documents (in the form of digital images) to conduct their investigations; the script is still undeciphered and presents itself like a 3D problem; there is no indication of the phonology of the language underlying the Proto-Elamite script; and the corpus is relatively small, making the use of statistical methods for pattern detection and cross-referencing less robust than with a larger corpus, as well as making the detection of errors and anomalies in the texts more arduous.

### 2.3. Models of the Act of Interpretation of Textual Artefacts

The tradition of publishing an interpretation of a textual artefact is similar in Assyriology and in Papyrology. In essence, before a whole corpus can be interpreted each textual artefact is published individually. Such an edition usually presents a transcription or transliteration of the text, a translation, if applicable, and a commentary relating the uncertainties and the extrapolations, the parallels and differences with similar texts, and the light it might shed on its given historical context. They are often accompanied by a photograph of the artefact and/or a line drawing of the textual artefact. Youtie, an eminent Papyrologist, describes these editions as “public Papyrology”. This “public” qualifier also holds for Assyriology of course. And the focus of my interest here is what happens before that; that is “what a Papyrologist [resp. Assyriologist] does privately in the solitary confines of the library, in order to make public Papyrology [resp. Assyriology] possible” (Youtie, 1963, p21). Previous studies by Terras (2006), in Papyrology, and by Ciula (2009), in Palaeography, have been directed towards understanding the private process of interpretation of ancient documents. Terras’s model identifies ten levels at which discussions of elementary interpretations can occur:

1. Archaeological or historical context.
2. Physical attributes of the document.
3. Features of the characters.
4. Identification of characters.

5. Identification of groups of characters.
6. Identification of words or morphemic units.
7. Grammar.
8. Meaning of a word.
9. Meaning of a group of words or phrase.
10. Meaning of the whole textual artefact.

Ciula's model identifies four stages of analysis in the production of the study of a script:

1. Segmentation, which separates letter shapes from the background and from one another.
2. Modelling, which turns letter shapes into ideal letter shapes.
3. Morphological parameterisation, which defines the degrees of variations allowed for a letter shape to fit a model of a letter.
4. Comparison and measures, which assesses the similarities and differences between various occurrences of the same letter.

Although designed specifically for papyrology and palaeography respectively, these models generalise well to the act of interpretation of textual artefacts in general, with the proviso of replacing the terms "letters" and "characters" by "graphemes" (by which, in the present paper we will mean the elementary unit of the writing system, i.e. logographs for assyriology, and characters for Latin.<sup>3</sup>) Both models can be seen as artefact-centred models as they describe what types of aspects of the document elicit what kind of interpretative responses. They were both devised with the computational intention of automating aspects of the interpretation task. Both models also show that one specific characteristic of an expert's act of interpretation is that an interpretation never emerges from the linear following of the stages they describe; this is made salient by Terras's observation of the constant oscillations between her levels of interpretation (Terras, 2005) and by Ciula's spiral along which her four stages of interpretation are positioned. The present research was undertaken to complement this object-centric view of private papyrology/assyriology with a human-centric approach in an attempt to identify more precisely expert cognitive processes that initiate the jumps between Terras's levels of reading and that propel Ciula's spiralling trajectories.

Taking forward the work started by Terras and Ciula, I have conducted an ethnographic study of papyrologists tackling the study of a Roman stylus tablet, and of assyriologists studying Proto-Elamite tablets. Attending their interpretation sessions (five 1 hour sessions with between four and six

assyriologists, and one 2hour session plus two 1hour sessions with two to five papyrologists) as well as concurrently filming them, I have transcribed and analysed the footage with the following specific objectives in mind:

1. Identify insight moments and the events that led to them.
2. Identify implicit and explicit methodologies, patterns, and strategies used by the experts, whether intellectual or practical.
3. Take special notice of mentions of materiality.
4. Single out discussions of uncertainties.

The following two sections report on my findings and attempt to link them back to studies rooted in the cognitive sciences where similar phenomena as those I have observed have been reported.

### **3. Perceptual Processes as Gateways to Knowledge**

In this section, I have grouped the processes related to motor and sensory feedback together and, rather artificially, separated them from conceptual processes as presented in the next section. Although these perceptual processes involve strongly the senses and the body, they do participate actively in cognition, and can thus be considered cognitive processes. Each of these processes can be mobilised at each one of the levels of interpretation described by either Terras's or Ciula's models and often initiate a shift to any one of the other levels of the considered model.

#### **3.1. Visual Feedback Loop**

The first striking element of the act of interpretation of either the Roman stylus tablets or of the Proto-Elamite clay tablets is that, when a direct access to the textual artefact is possible, experts always manipulate the object in such a way that the light plays with the three-dimensionality of the artefact. In particular, in applying a pitch-and-yaw motion to the artefact in raking light, experts accentuate the volumetric features of the object (Brady et al., 2005, Tarte, 2011). The motions of the cast shadows and strong highlights created by the pitch-and-yaw motions reveal the crests and troughs on the surface of the artefact. As the script in those tablets is by nature volumetric, this instinctive approach to the texts establishes a visual feedback loop where the 3D geography of the artefact is continually remapped in the experts' minds. Depth perception is facilitated and hence the text itself becomes more salient. Decades of research on human vision

have clearly established the link between motion and depth perception; they have further investigated whether (monocular) parallax motion is comparable to stereoscopic vision, and whether object motion and subject motion affect depth perception in the same way (Rogers and Graham, 1982, Larsen et al., 1983, Dijkstra et al., 1995). Rogers and Graham's study in particular concludes that there are some "striking similarities between the characteristics of the motion parallax and stereoscopic mechanisms with respect to the detectability of three dimensional corrugated surfaces" (Rogers and Graham, 1982, p269). This is particularly relevant here as it validates the (monocular) digitisation approach known as Reflectance Transformation Imaging (RTI; Malzbender et al., 2001, Earl et al., 2011) as an appropriate virtual pendant to pitch-and-yaw motion in raking light. In effect, RTI simulates pitch-and-yaw motion digitally by allowing for interactive relighting based on a continuous illumination model of the object built from a collection of digital images all captured from the same vantage point but with a different incident lighting angle. So that, whether considering the actual object or an RTI-digitised version of that object (which were used in the interpretation sessions I attended), experts can rely on the depth perception abilities of their visual system in order to identify the text-defining physical geography of the tablets. Through knowing that the text is incised in the artefact, experts are able to establish a visual feedback loop by looking to locate wedges, scratches, and depressions in the tablets in order to identify the text by relying on depth perception through parallax motion.

### 3.2. Kinaesthetic Feedback Loop

Another striking characteristic of the process of interpretation of textual artefacts such as Roman stylus tablets and Proto-Elamite clay tablets is the importance of the line drawings of the texts. They undoubtedly serve as a communication and validation device in discussions with other scholars, but beyond their role as a result presented in publications, the production of the line drawings itself participates in the act of interpretation. This phenomenon has already been observed and reported upon for papyrologists studying Roman stylus tablets (Tarte, 2011). It was dubbed the kinaesthetic approach to the texts and it was argued that the act of drawing contributed in establishing a feedback loop between the text as a shape and the text as a meaning. Intriguingly, a similar strategy called kinaesthetic facilitation has been used as early as 1892 to help patients affected by pure word blindness (also called pure alexia) to regain some capacity for reading. Alexia, an acquired form of dyslexia usually caused by lesions to the brain (to the left

occipital lobe for pure alexia), is characterised by the loss of the capacity to read both printed and cursive texts. In pure alexia, neither aphasia (loss of understanding and of capacity to utter spoken words) nor agraphia (loss of the capacity to write) are present. Through kinaesthetic facilitation, one of Déjerine's patients was able to read by tracing the letters with his finger (Déjerine, 1892, p63): "Ce malade, qui ne peut ni lire ni se relire, y arrive cependant en employant un artifice qui met en jeu son sens musculaire. En suivant du doigt les contours des lettres ou en les traçant dans le creux de sa main, il arrive à épeler des lettres et des mots." Case reports of observations of pure alexic patients are regularly published (e.g., Behrmann and McLeod, 1995, Bartolomeo et al., 2002, Ablinger and Domahs, 2009), as they have the potential to inform cognitive scientists on how the same semantic knowledge can be accessed by the visual appearance of letters and by their tracing.

These reports can be paralleled to the intuitive tracing of Latin texts by some papyrologists, although, of course, one main difference is that the level of fluency of the patients in their mother tongue (pre-alexia) differs in many ways from the fluency of papyrologists in Latin. Chances are, however, that resorting to tracing as a way of knowing mobilises the same kind of cognitive mechanism in both cases. More recent studies have actually shown that the premotor cortex is activated during the act of reading (Longcamp et al., 2003, Longcamp et al., 2005), showing that even without actually tracing them, some premotor processes are engaged in the recognition of letters and words. Kinaesthetic facilitation as a treatment of pure alexia is not restricted to alphabetic languages however and it has been used with some success in Japanese-speaking and Chinese-speaking patients (Seki et al., 1995, Bolger et al., 2005). Hence the action of drawing as a way of knowing doesn't have to be restricted to alphabetic languages as it also applies across logographic and syllabic writing systems. In order to draw some conclusion about the usefulness of tracing Proto-Elamite texts as a way of knowing however, one must consider that Proto-Elamite is still undeciphered, which is quite a stumbling block, as, in the cases of pure alexia, knowledge of the script and of the language would have probably been acquired approximately simultaneously. Studies reporting on learning to recognise pseudo-letters ([Longcamp et al., 2008, James and Atwood, 2009) however give some indication that even when not associating symbols with meaning or sound, motor engagement at the learning stage plays an important part in the ability to recognise and read pseudo-letters, whether the motor engagement is through typing or through tracing the pseudo-letters. So that both for Latin cursive and for Proto-Elamite, tracing the texts establishes a kinaesthetic feedback loop where knowledge of the signs influences the way they are

drawn and vice-versa. For Latin cursive, this engagement goes beyond shape recognition as traced letters go on to evoke sounds.

### 3.3. Aural Feedback Loop

When the language is known and some convention of how to pronounce it is available (as for Latin, although the convention doesn't claim to reflect the pronunciation of Latin as the Ancient people would have spoken it), then the sounds associated to the script also participate in the act of interpretation. A telling illustration of this aural feedback loop is the story of the identification of a "puzzling" letterform occurring in a Roman stylus tablet (Tarte):

[...]

(P2) *pointing at the letters while spelling them out: 'Q' 'U' 'E' 'D' 'R' 'E' 'T' 'U' 'S', 'QUEDRETUS'.*

(P3) *points at the problem letter on the screen.*

(P2) *wonderingly: 'QUADRATUS'? Read them as 'A's instead of 'E's?*

*Laughs.*

[...]

This excerpt of an interpretation session highlights the phonetic aspects of decipherment. In that respect, this approach can be compared to crossword or hangman puzzles solving, where the pronounceability of the portions of word already identified plays an important role. By sounding the words whilst integrating hypotheses of identification for the specific problematic letter, the proposed sound 'E' evoked a different sound, the sound 'A', thereby suggesting a new hypothesis of interpretation of the puzzling letterform. This type of approach is one of the ways in which the strategy that has been dubbed cruciverbalistic (analogous to cross-word puzzle solving (Tarte, 2011) is implemented. In fact, studies investigating the processes involved in crossword puzzle solving have concluded that there is some "evidence for the existence of lexical subunits that are larger than the letter but smaller than the word, and that are organized according to phonologic principles" so that, "As syllables appear to be the best cue for word retrieval, we suggest that syllabic units have a strong lexical reality." (Goldblum and Frost, 1988, p164). A more recent study claims: "An argument can be made that although we can search our lexicons on the basis of either phonological or orthographic features of words, for most of us a phonological search is the more natural one" (Nickerson, 2011). Although these studies were conducted with English as a language of study, there is no reason to think that the aural feedback loop established by sounding out portions of words wouldn't also apply to any other alphabetic language,

including to Latin, at which papyrologists are experts. The phonological aspects of word identification need to be further investigated for syllabic and logographic languages,<sup>4</sup> but in the case of Proto-Elamite, as no pronunciation convention exists, some other non-phonological and probably more conceptual mechanisms are mobilised during the decipherment task.

The perceptual processes singled out here continually interact with conceptual processes through feedback loops. For example: “Grammar resides in the neural connections between concepts and their expression via phonology. That is, grammar is constituted by the connections between conceptual schemas and phonological schemas. Hierarchical grammatical structure is conceptual structure. Linear grammatical structure is phonological” (Gallese and Lakoff, 2005), so that phonological information allows for easy access to semantic memory.

## **4. Conceptual Processes as Gateways to Knowledge**

The feedback loops listed in the previous section only become effective sense-making mechanisms if they integrate mechanisms that allow for knowledge to grow. In order to build interpretations of ancient textual artefacts, experts reason around hypotheses of interpretation and uncertainties via access to semantic memory and acquisition of structural knowledge. Creativity, insight, and collaboration further help them advance in their interpretation endeavour.

### **4.1. Semantic Memory and Abstractions**

Crossword puzzle solving as a method of enquiry is conceptually well suited to explore the decipherment of ancient scripts, in spite of the different nature of the (alphabetic) Latin and (syllabic/logographic) Proto-Elamite scripts under scrutiny here. Due to the damaged, fragmentary, and abraded nature of ancient textual artefacts, the act of reading them has more similarities with the solving of word puzzles than it does with linear reading. So that, contrary to linear text reading, if some structural clues can be gathered in crossword puzzles (e.g. length of words/entries), contextual information related to meaning is limited. I have presented how phonological clues take part in the reading of textual artefacts, however visual clues are the dominant part of the context informing experts and helping them to identify graphemes through their shape. Psychological studies analysing the reading of degraded or partially obscured words in modern scripts shed a

further light on the conceptual processes at play (McClelland and Rumelhart, 1981, Cohen et al., 2008). One of the building blocks of the so-called connectionist model of mind has demonstrated a phenomenon called the word superiority effect. The word superiority effect manifests itself as follows: “In conditions of degraded (but not abbreviated) input, the role of the word level is to selectively reinforce possible letters that are consistent with the visual information extracted and that are also consistent with the words in the subject’s vocabulary” (McClelland and Rumelhart, 1981, p391), so that “ [...] any grouping of letters is more facilitative in retrieving words from memory than are dispersed letters. [...] It appears that the information afforded by a given set of clustered letters is more than the sum of the information afforded by each of the cluster’s constituents alone” (Goldblum and Frost, 1988, p163). The presence and combination of certain graphemes along with the prior knowledge of the experts conditions them to expect or reject the presence of other specific graphemes. One example from the interpretation sessions with papyrologists is the following utterance, happening a little earlier than the excerpt quoted above, at a different location on the artefact:

[...]

(P1) If you agree with ‘QUEM’ you don’t want a ‘D’ before it... unless it’s ‘AD QUEM’? It could be...

(P2): It’s the kind of thing you would find in a legal text, really.

[...]

A similar example occurred in one of the sessions with the assyriologists:

[...]

(A1), *referring to another textual artefact than the one under scrutiny:*

But this text starts with a different sign, and then something broken, and then a very large barley notation, and then you have: one of these, one of these, and then a sign for plough. A sign that simply looks like a plough; and then the barley sign, and a very large notation —a laaarge notation— you can see the plough sign here again; it’s clearer here, and you see: this sign, one of those, plough, barley container —thousands of them. Yeah?

[...]

(A1) *switching his attention back to the tablet under scrutiny:*

So what if this text really says: [...]

It’s a prepend text in that case. These are the fields from which we sustain the staff... \*sigh\* but there’s no plough sign. I can’t see a plough sign, it should be there then. Could it be there?

[...]

What seems to be happening in both these examples is a mobilisation of semantic memory, where, based on surrounding graphemes, scholars hypothesise about missing or difficult graphemes by referring to their expert knowledge—an expert knowledge that naturally shapes their expectations. Through the crossword paradigm as studied in the cognitive sciences, it is possible to highlight aspects of the workings of human cognition relating to “word associations, lexical memory search, semantic priming” (Nickerson, 2011, p217), and to explore the nature of expertise (Underwood et al., 1994). One of the facets of cognition that is at play in expertise and that seems particularly relevant to the act of interpretation of textual artefacts involves “functional, abstracted representations of presented information” (Feltovich et al., 2006, p50). In particular, according to the Feltovich citing Zeitz (1997), there are five ways in which experts manipulate so-called Moderately Abstracted Conceptual Representations (MACRs): (1) retrieval from memory; (2) integration of information, along with its saliency, relevance, and significance; (3) guidance and justification for the adoption of a given strategy; (4) the use of analogy in reasoning; and (5) the use of tools for reasoning and for the evaluation of alternatives. In the excerpts above, scholars appear to be continually using MACRs for retrieval, analogy, and reasoning, and these MACRs contribute to the perceptual feedback loops listed in the previous section.

## 4.2. Structural Knowledge and Familiarity

Two of the characteristics of experts are that they perceive deep structures in the problems and situations of their domain of expertise, and they analyse them qualitatively through the development of abstracted representations and models (Chi, 2006). Publications presenting the overall structures of certain types of textual artefacts illustrate well how this conscious structural knowledge contributes to the understanding of the artefacts under scrutiny (e.g. Englund, 2004 for Proto-Elamite tablets, and Battezzato, 2009 for ancient Greek papyri). Structures of texts and layout are very rich in information, and experts are very good at making use of them. They even sometimes use the contextual information unconsciously, to the point that when asked to justify their interpretation, they are at a loss to formulate an explanation:

[...]

(P1): I think that's right, I think that must be an 'A'... So it's a fourth century 'A' in a first century text!!?!!

(P2) *acquiesces.*

(P1) There's no way this is a fourth century text.

(P3) Why?

(P1) Good question!

(P2) That 'L' is not a very early 'L'. Could be a second century text.

(P1) Well, of course, if it's a different kind of text completely!

[...]

This excerpt illustrates how knowledge has been internalized; P1, P2, and P3 all have several decades of papyrological and ancient Latin palaeographical experience. But during the learning phase before experts become experts, when they are exposed to implicitly structured patterns, knowledge of underlying structures are acquired albeit not consciously. This phenomenon has been demonstrated by experiments in Artificial Grammar Learning (AGL; Dienes and Scott, 2005, de Vries et al., 2008, Scott and Dienes, 2010, Meador and Dienes, 2012). In the AGL paradigm, subjects are first presented with a list of non-pronounceable words made with a small alphabet (e.g., 'M', 'T', 'V', 'R', 'X', as in Dienes and Scott, 2005) following an artificial grammar that sets the rules governing the formation of words. In the training phase, subjects are unaware of the grammar itself. They are then told that a set of rules governed the formation of the words that they have learned (by copying them), and asked to determine whether each item in a new list of words follows these rules. They are also asked to qualify their answers by judging them as: guess work, intuition, familiarity, recollection, or rule enunciation. An above chance proportion of correct responses were qualified by intuition and familiarity, showing that although there is no explicit recollection or rule enunciation, structural knowledge was acquired by exposure to the structured script. The existence of this unconscious structural knowledge explains why, in spite of the lack of explicit grammar enunciated in Proto-Elamite today, experts still have some understanding of the texts. Their constant and repeated exposure to the tablets will have contributed to their building of an unconscious hence implicit knowledge of Proto-Elamite. Scholarship however is about building an explicit body of knowledge. So what kind of strategies can be developed to turn unconscious knowledge into a conscious knowledge that can be communicated?

### 4.3. Collaboration, Insight and Creativity

The transition from unconscious to conscious knowledge often happens through "Aha!" moments, through creative impulses, and through collaborations:

[...]

(A1) There's a very interesting point; that is that there has never been a

decipherment done by one person. You can't do that, because you always think one way. You think this must be like this because this is how I look at it, it's how I see it, it's like I understand. And until now we had the images of the text; there was no real way that two people could work on it. Because it is really meaningless if I was teaching these texts showing you an image, the old images, and telling you "but that is wrong, you have to believe what I have seen when I went there". Well now we can actually share these images (*the RTI images*) with different researchers and hopefully we won't limit them so much because we have the RTIs where we can modify the light so that if I missed an angle the (other) researchers can do that themselves.  
[..]

While expertise is conditioned by proficiency acquired via training, it also is, to some extent, related to individual talent and personal network: "Acquiring expertise is not solely a cognitive matter. Personal interests and social support are also very important" (Hunt, 2006, p31). So that pooling expert skills and talents around a task can help trigger insight moments. Studies analysing creative problem solving have identified a number of mechanisms that can foster insights (Bowden et al., 2005, Kirsh, 2009, Cushen and Wiley, 2011). Relaxation of self-imposed constraints and reframing of the problem are such mechanisms; defamiliarisation, task switching, and self-cueing are also such mechanisms; and they can all be facilitated in collaborative situations. These mechanisms occurred throughout each of the interpretation sessions. Self-cueing manifested itself clearly through mobilisation of perceptual feedback loops, where sensory-motor engagement such as tracing the texts, sounding the words, and modifying illumination conditions in RTI images allowed for progress. Task-switching occurred naturally due to the non-linearity of the act of interpretation itself; experts usually first tackle areas of the textual artefact where the writing seems the most legible and once some (often dispersed) words have been identified, they are used as seed-points from which decipherment can be expanded. Reframing and relaxing of self-imposed constraints happens each time experts have to negotiate the tensions between their expectations and what the artefact expresses, as illustrated by the example of the "4<sup>th</sup> century 'A' in a 1<sup>st</sup> century text".

## 5. Conclusion

Based on an ethnographic study of papyrologists and assyriologists, I have been able to identify some of the cognitive processes that they mobilise

when setting out to interpret ancient textual artefacts and I have further linked my observations to findings from the cognitive sciences literature; these cognitive processes involve sense-making feedback loops drawing on perceptual and conceptual processes. The perceptual processes I have identified demonstrate the strong physical and sensory engagement of the experts with the textual artefact under scrutiny: the materiality of the object spurs a specific visual engagement that draws on depth perception through parallax motion; motor engagement enables experts to establish a connection between the script as a shape and the script as a meaning; and the sounding of words or syllables allows for effective word searches and recognition. These perceptual processes are in constant interaction with conceptual processes and allow for the establishment of sense-making feedback loops. The conceptual processes that I have identified resort to: semantic memory and moderately abstracted conceptual representations for effective access to pre-existent expert knowledge; conscious and unconscious structural knowledge of patterns in writing systems; and strategies that support collaboration, insight, and creativity by ways of reframing, self-cueing, and task-switching. Research in the cognitive sciences is investigating these cognitive processes and the ways they work with each other in controlled laboratory experiments or via case studies. Each of the studies I have referred to in this paper subscribes to some more general theory of cognition, and sometimes these underlying theories contradict each other. However, all the phenomena that they are reporting are relevant to the (non-lab) settings of the study of experts interpreting ancient textual artefacts, so by using the aspects of the theories that are relevant to the cognitive processes under investigation, one can build cognitive-enabling digital tools that integrate those aspects of the theory and simultaneously test the theory in the wild. Ultimately, each of these theories has the potential to inform scholars in the Humanities on how they create knowledge and thereby provide them with a supporting framework. By taking these findings out of the lab settings and comparing them to observations gathered in more naturalistic settings I hope to be able to develop some digital tools, which rather than aiming for automation or semi-automation will support experts in their task as much as possible and even potentially trigger some of the cognitive-enabling mechanisms presented here. For example, bringing together RTI images with multi-touch surfaces technology would allow for the gathering in one tool of the three following cognitive-enabling mechanisms: interactive illumination of the textual artefact to fosters the visual feedback loop; multi-user enabled tracing of the script on images of the textual artefact to foster both collaboration and the kinaesthetic feedback loop.

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## 7. References

Ablinger, I. and Domahs, F. Improved single-letter identification after whole-word training in pure alexia. *Neuropsychological Rehabilitation*, 2009. 19(3), 340—363. PMID: 19191066.

Bartolomeo, P., Bachoud-Lévi, A.-C., Chokron, S., and Degos, J.-D. Visually- and motor-based knowledge of letters: evidence from a pure alexic patient. *Neuropsychologia*, 2002. 40(8), 1363 — 1371.

Battezzato, L. Techniques of reading and textual layout in ancient greek texts. *The Cambridge Classical Journal (New Series)*, 2009. 55, 1—23.

Behrmann, M. and McLeod, J. Rehabilitation for pure alexia: Efficacy of therapy and implications for models of normal word recognition. *Neuropsychological Rehabilitation*, 1995. 5(1-2), 149—180.

Bolger, D. J., Perfetti, C. A., and Schneider, W. Cross-cultural effect on the brain revisited: Universal structures plus writing system variation. *Human Brain Mapping*, 2005. 25(1), 92—104.

Bowden, E. M., Jung-Beeman, M., Fleck, J., and Kounios, J. New approaches to demystifying insight. *Trends in Cognitive Sciences*, 2005. 9(7), 322 — 328.

Bowman, A. K. *Life and Letters on the Roman Frontier -Vindolanda and its people*. The British Museum Press, 1995. 3rd (2003) edition.

Bowman, A. K. and Tomlin, R. S. O. *Wooden stilus tablets from Roman*

Britain. In Bowman, A. K. and Brady, M., editors, *Images and Artefacts of the Ancient World*, volume 4 of *British Academy Occasional Paper*, 7–14. Oxford University Press/British Academy, Oxford, 2005.

Brady, M., Pan, X., Schenck, V., Terras, M., Robertson, P., and Molton, N. Shadow stereo, image filtering and constraint propagation. In Bowman, A. K. and Brady, M., editors, *Images and Artefacts of the Ancient World*, volume 4 of *British Academy Occasional Paper*, 15–30. Oxford University Press/British Academy, Oxford, 2005.

Bülow-Jacobsen, A. Writing materials in the ancient world. Ed. Bagnall, R. S., *The Oxford Handbook of Papyrology*, 3–29. Oxford University Press, Oxford, 2009.

Chi, M. T. H. Two approaches to the study of experts' characteristics. Ericsson et al., 2006, chapter 2, 21–30.

Ciula, A. The Palaeographical Method Under the Light of a Digital Approach. In Rehbein, M., Sahle, P., and Schaßan, T., editors, *Kodikologie und Paläographie im digitalen Zeitalter - Codicology and Palaeography in the Digital Age*, volume 2 of *Schriften des Instituts für Dokumentologie und Editorik*. Books on Demand, 2009.

Cohen, L., Dehaene, S., Vinckier, F., Jobert, A., and Montavont, A. Reading normal and degraded words: Contribution of the dorsal and ventral visual pathways. *NeuroImage*, 2008. 40(1), 353 – 366.

Crystal, D. *The Cambridge Encyclopedia of Language*. Cambridge University Press, 1987.

Cuneiform Digital Library Initiative. 2013. <http://www.cdli.ucla.edu>. Last visited: 01/07/2013

Cushen, P. J. and Wiley, J. Aha! voila! eureka! bilingualism and insightful problem solving. *Learning and Individual Differences*, 2011. 21(4), 458 – 462.

de Vries, M., Monaghan, P., Knecht, S., and Zwitserlood, P. Syntactic structure and artificial grammar learning: The learnability of embedded hierarchical structures. *Cognition*, 2008. 107(2), 763 – 774.

Déjerine, J. Contribution à l'étude anatomo-pathologique et clinique des différentes variétés de cécité-verbale. *Mémoires de la Société de Biologie*,

1892. 4, 61—90.

Dienes, Z. and Scott, R. Measuring unconscious knowledge: distinguishing structural knowledge and judgment knowledge. *Psychological Research*, 2005. 69, 338—351. 10.1007/s00426-004-0208-3.

Dijkstra, T., Cornilleau-Pérès, V., Gielen, C., and Droulez, J. Perception of three-dimensional shape from ego- and object-motion: Comparison between small- and large-field stimuli. *Vision Research*, 1995. 35(4), 453 — 462.

Earl, G., Basford, P. J., Bischoff, A. S., Bowman, A., Crowther, C., Hodgson, M., Martinez, K., Isaksen, L., Pagi, H., Piquette, K. E., and Kotoula, E. Reflectance transformation imaging systems for ancient documentary artefacts. In *Electronic Visualisation and the Arts*, London, UK, 2011. BCS, The Chartered Institute for IT.

Englund, R. K. The state of decipherment of proto-elamite. In Houston, S., editor, *The First Writing: Script Invention as History and Process*, 100—149. Cambridge University Press, 2004.

Ericsson, K. A., Charness, N., Feltovich, P. J., and Hoffman, R. R., editors. *The Cambridge Handbook of Expertise and Expert Performance*. Cambridge University Press, 2006.

Feltovich, P. J., Prietula, M. J., and Ericsson, K. A.. Studies of expertise from psychological perspectives. Ericsson et al., 2006, chapter 4, 41—67.

Gallese, V. and Lakoff, G.. The brain's concepts: the role of the sensory-motor system in conceptual knowledge. *Cognitive Neuropsychology*, 2005. 22(3/4), 455—479.

Goldblum, N. and Frost, R. The crossword puzzle paradigm: The effectiveness of different word fragments as cues for the retrieval of words. *Memory & Cognition*, 1988. 16, 158—166. 10.3758/BF03213485.

Hunt, E. Expertise, talent and social encouragement. Ericsson et al., 2006, chapter 3, 31—38.

James, K. H. and Atwood, T. P. The role of sensorimotor learning in the perception of letter-like forms: Tracking the causes of neural specialization for letters. *Cognitive Neuropsychology*, 2009. 26(1), 91—110.

Kirsh, D. Problem solving and situated cognition. In Robbins, P. and Aydede,

M., editors, *The Cambridge Handbook of Situated Cognition*, 264—306.  
Cambridge University Press, Cambridge, 2009.

Larsen, A., Farrell, J. E., and Bundesen, C. Short- and long-range processes in visual apparent movement. *Psychol Res*, 1983. 45, 11—18.

Longcamp, M., Anton, J.-L., Roth, M., and Velay, J.-L. Visual presentation of single letters activates a premotor area involved in writing. *NeuroImage*, 2003. 19(4), 1492 — 1500.

Longcamp, M., Anton, J.-L., Roth, M., and Velay, J.-L. Premotor activations in response to visually presented single letters depend on the hand used to write: a study on left-handers. *Neuropsychologia*, 2005. 43(12), 1801 — 1809.

Longcamp, M., Boucard, C., Gilhodes, J.-C., Anton, J.-L., Roth, M., Nazarian, B., and Velay, J.-L. Learning through hand- or typewriting influences visual recognition of new graphic shapes: Behavioral and functional imaging evidence. *Journal of Cognitive Neuroscience*, 2008. 20(5), 802—815.

Malzbender, T., Gelb, D., and Wolters, H. Polynomial texture maps. In *SIGGRAPH '01: Proceedings of the 28th annual conference on Computer graphics and interactive techniques*, 519—528, New York, NY, USA. ACM, 2001.

McClelland, J. L. and Rumelhart, D. E. An interactive activation model of context effects in letter perception: Part I. An account of Basic Findings. *Psychological Review*, 1981. 88(5), 375—407.

Mealor, A. and Dienes, Z. Conscious and unconscious thought in artificial grammar learning. *Consciousness and cognition*, 2012. 21, 865—74.

Nickerson, R. S. Five down, absquatulated: Crossword puzzle clues to how the mind works. *Psychonomic Bulletin & Review*, 2011. 18(2), 217—41.

Rogers, B. and Graham, M. Similarities between motion parallax and stereopsis in human depth perception. *Vision Research*, 1982. 22(2), 261 — 270.

Scott, R. and Dienes, Z. The metacognitive role of familiarity in artificial grammar learning: Transitions from unconscious to conscious knowledge. In Efklides, A. and Misailidi, P., editors, *Trends and Prospects in Metacognition Research*, Springer US, 2010. 37—61.

Seki, K., Yajima, M., and Sugishita, M. The efficacy of kinesthetic reading treatment for pure alexia. *Neuropsychologia*, 1995. 33(5), 595 — 609.

Tarte, S. M. Papyrological Investigations: Transferring Perception and Interpretation into the Digital World. *Lit Linguist Computing*, 2011. 26(2), 233—47.

Terras, M. Reading the readers: Modelling complex humanities processes to build cognitive systems. *Lit Linguist Computing*, 2005. 20, 41—59.

Terras, M. *Image to Interpretation. An Intelligent System to Aid Historians in Reading the Vindolanda Texts*. Oxford University Press, Oxford, 2006.

Underwood, G., Deihim, C., and Batt, V. Expert performance in solving word puzzles: From retrieval cues to crossword clues. *Applied Cognitive Psychology*, 1994. 8(6), 531—548.

Vindolanda Tablets Online. 2003. <http://vindolanda.csad.ox.ac.uk>. Last visited: 01/07/201

Youtie, H. C. The papyrologist: artificer of fact. *Greek, Roman and Byzantine Studies*, 1963. 4(1), 19—33.

Zeitz, C. M. Some concrete advantages of abstraction: how experts' representations facilitate reasoning. In Feltovich, P. J., Ford, K. M., and Hoffman, R. R., editors, *Expertise in context*, 43—65. MIT Press, Cambridge, MA, USA, 1997.

## Footnotes

<sup>1</sup> *Vindolanda tablets online*. <http://vindolanda.csad.ox.ac.uk>. 2003. Last visited: 01/07/2013.

<sup>2</sup> *Cuneiform digital library initiative*. <http://www.cdli.ucla.edu/>. 2013 Last visited: 01/07/2013.

<sup>3</sup> Strictly speaking, a grapheme is “the smallest unit in a writing system capable of causing a contrast in meaning” (Crystal, 1987. 194). Based on this definition, and keeping in mind that Proto-Elamite is still undeciphered, it is unclear whether the choice of the word grapheme to designate a sign is *sensu stricto* appropriate; in fact some signs seem to be clearly composed of sub-signs, but it is unknown whether or how they might be sense-carrying. The use of the word grapheme to designate a Proto-Elamite sign is hence explicitly stated here as a *convention*; this convention is used by extension and for ease of expression throughout this paper so that the term grapheme might designate a Proto-Elamite sign, a character of the Latin alphabet, as well as a character of the Chinese or of the Japanese scripts (some of which are in fact composites of smaller sense-carrying subunits).

<sup>4</sup> The question poses itself as to the suitability of the crossword analogy and method of enquiry for non-alphabetic scripts as the smallest graphical units (graphemes) correspond to syllables in a syllabic script, and to words in logographic scripts, whilst graphemes correspond to phonemes in an alphabetic script. In practice, Chinese, a logographic script, has crosswords too, but instead of operating at the word level like alphabetic languages do, they operate at the phrase level; i.e. as each grapheme represents a word, crossword clues describe a saying or a sentence, effectively making crossword puzzles into “crossphrase” puzzles. In Japanese, which has three writing systems, of which one is logographic (Kanji) and two are syllabic (Katakana and Hiragana), crossword puzzles do not usually mix the different scripts and are mostly made in the Katakana script, at the word level.