A Perfect Pangram:
A Reconsideration of the Evidence

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I N THE LAST DECADE there has been increasing interest in the art of ancient Greek puzzles, riddles, isopsephism, 'picture-poems' (*Figurengedichte*), and other instances of verbal, pictorial, and numerical manipulations that are sometimes cast under the term of *technopaignia*.[1] This new interest is marked by more attention paid to individual objects, their material aspects, to the format and arrangement of writing on them, than to reconstruction and, especially, evaluation of the *Urtext*. Consequently, the tendency to use definitive labels for instances of *technopaignia*—from "school texts" to "expensive rubbish [which] belonged in the homes of the nouveaux riches"[2]—has yielded to the open-ended exploration of cultural, religious, or literary practices that may be associated with the production and consumption of such objects and texts.[3] It is in the spirit of this kind of inquiry that I propose a reexamination of a well-known perfect pangram, that is, a sentence-like sequence that contains every letter of the alphabet employed

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[1] This is exemplified by such monographs as C. Luz, *Technopaignia, Formspiele in der griechischen Dichtung* (Leiden 2010); M. Squire, *The Iliad in a Nutshell: Visualizing Epic on the Tabulae Iliacae* (Oxford 2011); or J. Kalvesmaki, *The Theology of Arithmetic: Number Symbolism in Platonism and Early Christianity* (Washington 2013).

[2] N. Horsfall, "Stesichorus at Bovillae?" *JHS* 99 (1979) 46, on the *Tabulae Iliacae*.

[3] This change of orientation in the researcher's quest is perhaps best described on a more general level by B. Latour, *Reassembling the Social* (Oxford 2005).

only once.[4] I hope to demonstrate that the fortuitous survival of some material evidence makes manifest hitherto-unnoticed features of the pangram and helps elucidate potential practices associated with its composition and inscribing.

The evidence

Three perfect pangrams are known from antiquity: (1) μάρπτε σφὶγξ κλὼψ ζβυχθηδόν, (2) βέδυ ζὰψ χθὼμ πλῆκτρον σφίγξ, and (3) κνὰξ ζβὶ χθὺ πτὴς φλεγμὸ δρώψ.[5] Of these, the third, the κνάξ-pangram, is by far the best attested not only in terms of the number of occurrences, but, more importantly, by its survival on a variety of objects, such as papyrus, wooden tablets, and ceramic fragments. Chronologically, it spans almost a millennium, with occurrences dispersed geographically from Upper Egypt in the south, to the area of modern Montpellier in the north and west, and to Ephesos in the east. It is on this pangram that my study concentrates.

Sources for the κνάξ-pangram can be divided into literary (I) and documentary (II). For the sake of convenience, here follows a list of attestations of the pangram, whether whole or in part, with an indication of the object on which it is inscribed as well as other writings in connection with which it occurs. In the rest of the paper, I will be using the numbers from this list to refer to individual instances; the asterisk (*) marks those cases where only the letters κναξ without the rest of the sequence appear.

I. *Literary evidence*

1 Clem. Alex. *Stromata* 5.8.48.5–9.

2 Fragment ascribed to Porphyry in MS. *Bodl.gr.Barocci* 50, 353ᵛ.15–354ʳ.13.[6]

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[4] For reasons discussed below I avoid the commonly used term *chalinos* to refer to this and other pangrams.

[5] Clem. Al. *Strom*. 5.8.46–49 (ed. A. Le Boulluec, *Clément d'Alexandrie, Les Stromates V* [Paris 1981]). Luz, *Technopaignia* 115–132, is the most recent comprehensive study of all three pangrams.

[6] C. Callanan, "A Rediscovered Text of Porphyry on Mystic Formulae," *CQ* 45 (1995) 215–230.

3 Hesychius (κ 3084, ζ 85, θ 920, δ 2468, φ 585).

4* Ammonius *In Aristotelis librum de interpretatione* pp.30.19, 51.19, *In Porphyrii isagogen* pp.59.1, 60.7 (ed. Busse): κναξ only.

5* Olympiodorus, *In Aristotelis categorias commentarium* p.53.18 (ed. Busse): κναξ only.

II. *Documentary evidence*

6 *SEG* XLIII 680.9 (TM 322171 = LDAB 322171: Lattara, late 3rd c. B.C.?)[7] (*fig.* 1). The sherd is broken on the right and has the following text incised:

ᵛ αβγδ[
κναξ[
vac.
ϛ .
_ _ _
3 or ζ. [: τω[ed.pr.

7 *MPER* N.S. IV 7 (TM 63194 = LDAB 4399: Hermopolis? 1st c.). The papyrus has various alphabetic sequences, as well as numerals and syllabaries.

8 *P.Köln* IV 175 (TM 62079 = LDAB 3239: unknown provenance, 5th c.). The papyrus seems to have been used for 'Schriftproben' that feature citations from psalms, a partly preserved κνάξ-pangram, and a variant of a pangram verse known from many attestations, including *Anth.Gr.* 9.538 (Ἀβροχίτων δ᾽ ὁ φύλαξ θηροζυγοκαμψιμέτωπος).

9 *P.Kellis* I 82 (TM 109540 = LDAB 109540: 4th c.). This wooden tablet with a calendar of good and bad days has part of the pangram inscribed (and perhaps also once attempted) on the verso along with a possible invocation of a god or daemon.[8]

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[7] Ed. pr. M. Bats, "Les inscriptions et graffites sur vases céramiques des Lattara proto-historique," *Lattara* I (1988) 147–160; accompanied by extended and updated archaeological information in M. Py et al., *Corpus des céramiques de l'âge du Fer de Lattes* I (= *Lattara* XIV [Lattes 2001]) 541–542, no. 2932. The alphabetic formula in line 2 has been recognized by J.-L. Fournet, "Au sujet du plus ancien *chalinos* scolaire: *chalinoi* et vers alphabétiques grecs," *RPhil* 74 (2000) 61–82.

[8] The editor prints in lines 34–35 (m. 2) κναξ ζβιχθυ / πτης (m. 3) φφε and in line 39, which is said to be upside down ("180° turned"), (m.2) κναξ[. Unfortunately, I have not been able to verify the readings and the change of hands, as no photograph of the verso has been published; my

10 *P.Lond.Copt.* 1102 (Hermopolis, 4th–early 5th c.). On the verso of a private letter in Coptic, there are said to be two preliminary attempts to write the κνάξ-pangram followed by a successful one written thus: κναξζβιχθυ/πτησφλεγ/μοδρ/ωψ.[9]

11 T. Louvre inv. AF 1193 (TM 64906 = LDAB 6145: Antinopolis, 5th–6th c.) (*fig.* 2). The tablet has the pangram (verso) and a sequence of rearranged letters of the alphabet (recto), both inscribed in a tabular form.[10]

12 Unpublished (inv. HH1, Ki 64, 90/68: Ephesos, time of Augustus). This small sherd, broken on the left, has remnants of two alphabets, one of which is in reversed order, and of two perfect pangrams, κνάξ- and βέδυ-.[11]

13* Schoolmaster's handbook[12] (TM 59942 = LDAB 1054: Arsinoite? 3rd c. B.C.). The roll, the beginning of which is lost, contains a book of exercises that proceed from syllabaries to various lists and then to literary passages; κνάξ (line 36) appears there in a list of monosyllabic words.

14*? *P.Pintaudi* 62 (TM 144559 = LDAB 144559, unknown provenance, ca. 400–525). A piece of parchment inscribed with what the editor calls "entrainements calligraphiques" may have had the pangram or part of it inscribed in line 1.[13]

The Lattara sherd (**6**) is possibly the earliest attestation of the complete κνάξ-pangram: even though only these four letters survive, the fact that the beginning of the alphabet is written

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attempts to locate a photograph have been unsuccessful.

[9] The text is after Fournet, *RPhil* 74 (2000) 64.

[10] B. Boyaval, "Tablettes du Louvre en provenance d'Egypte," *RevArch* N.S. 1 (1971) 57–70, no. 2.

[11] I am grateful to Dr. Sabine Ladstätterthe, director of the Austrian Archaeological Institute, and Dr. Patrick Sänger, who is preparing a publication of inscribed sherds from Ephesos, for allowing me to mention this find.

[12] O. Guéraud and P. Jouguet, *Un livre d'écolier* (Cairo 1938).

[13] The editor, J.-L. Fournet, reads there . κνα[and adducing as parallel *P.Köln* IV 175 (**8**) cautiously suggests that the traces belong to the pangram. The apparent traces of a letter before kappa, however, add some doubt to this otherwise attractive identification.

Fig. 1. Ceramic sherd found in Lattara, 225–200 B.C.
(*Corpus des céramiques de l'âge du Fer de Lattes*, no. 2932)
Photograph © Michel Py

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Fig. 2. Wooden tablet from Antinopolis, 5th–6th c., verso
(Louvre inv. AF 1193v)
Photograph ©Musée du Louvre/Georges Poncet

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above them and that the sherd is broken on the right strongly suggests that both lines originally continued. Jean-Luc Fournet argues that like many other attestations of the sequence, the sherd points to a school context, and with its date in the late third or early second century B.C. attests extreme stability of Greek pedagogical methods over a long period of time.[14] While it may well be so, a 'school' label by itself raises more questions than it answers, the most immediate one being what educational purpose a scrambled alphabet could have served. It has been generally accepted that such sequences are to be identified with *chalinoi*,[15] a kind of tongue-twister used to improve a child's pronunciation, the description of which is owed Quintilian, who commends the practice:[16]

[14] Fournet, *RPhil* 74 (2000) 65; cf. R. Cribiore, *Writing, Teachers, and Students in Graeco-Roman Egypt* (Atlanta 1996) 39–40; W. Johnson, "Learning to Read and Write," in W. M. Bloomer (ed.), *A Companion to Ancient Education* (Malden 2015) 141–142.

[15] The identification seems to go back to C. A. Lobeck, *Paralipomena grammaticae graecae, pars prior* (Leipzig 1837) 118–119 n.45, who, in his discussion of words ending in -ωψ, adduces δρώψ and takes issue with Bentley's supposition, expressed in his comments on the Oxford passage of Porphyry, that sentences composed of words like δρώψ (δρόψ in the Oxford MS.) were meant for exploration of meaning ("Quis autem homo sanus pueris ejusmodi Abracadabra interpretandum proponat?" "What sane man would ever submit to children an Abracadabra of this sort for interpretation?"). Rather, Lobeck contends that they were meant for improving a child's pronunciation and he cites Quintilian's discussion of *chalinoi* to support his suggestion, although he does cut the quotation short, right before Quintilian explicitly mentions *chalinoi*. The word χαλινός means "bridle" or "rein" and can be applied to anything that compels or restrains, literally or metaphorically.

[16] *Inst.* 1.1.37: *non alienum fuerit exigere ab his aetatibus, quo sit absolutius os et expressior sermo, ut nomina quaedam versusque adfectatae difficultatis ex pluribus et asperrime coeuntibus inter se syllabis catenatos et veluti confragosos quam citatissime volvant; chalinoi Graece vocantur. res modica dictu, qua tamen omissa multa linguae vitia, nisi primis eximuntur annis, inemendabili in posterum pravitate durantur.*

it will be worthwhile, by way of improving the child's pronunciation and distinctness of utterance, to make him rattle off a selection of names and lines of studied difficulty; they should be formed of a number of syllables which go ill together and should be harsh and rugged in sound: the Greeks call them *chalinoi*. This may seem a trivial matter, but its omission will result in many faults in language, which if not removed in the early years, will become an irreparable deformity and persist for life.

Quintilian does not cite any of the *chalinoi*, nor does he suggest that they should contain all the letters of the alphabet employed only once, a property which in fact puts constraints on potential logopedics.[17] Clement of Alexandria (**1**), who cites the three perfect pangrams, uses the term ὑπογραμμὸς παιδικός,[18] a "copy-head for children," that is, a sentence that a pupil was perhaps expected to copy, and although it is not immediately clear what the student stood to gain by the process, no training in enunciation seems to be implied.

It is of course difficult to assess what combinations of sounds could vex an ancient student. However, Dionysius of Halicarnassus (*Comp.* 16) provides some hints by citing examples that would not surprise a modern speech therapist. Thus, he deems those passages that are thickly studded with combinations of fricatives and mute consonants most difficult to pronounce (τὰ δυσεκφορώτατα). To illustrate this point he adduces verses that abound in alliteration and consonance, *Odyssey* 6.137 σμερδαλέος δ' αὐτῇσι φάνη κεκακωμένος ἅλμῃ, and *Iliad* 11.36–37 τῇ δ' ἐπὶ μὲν Γοργὼ βλοσυρῶπις ἐστεφάνωτο / δεινὸν δερκομένη, περὶ δὲ Δεῖμός τε Φόβος τε. Although Dionysius gives no advice on improving a child's pronunciation, verses that he singles out

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[17] Cf. modern speech therapy in which sequences of words featuring similar sounds are used to improve one's pronunciation: see e.g. S. Eberhart and M. Hinderer, *Stimm- und Sprechtraining für den Unterricht*[2] (Padeborn 2016), esp. 112–126.

[18] To be precise, Clement uses no terminology in his discussion of the first two sequences, but the third is introduced as ἀλλὰ καὶ τρίτος ὑπογραμμὸς φέρεται παιδικός (5.8.49).

as particularly difficult to pronounce fit very well Quintilian's prescription.

That the 'word' κνάξ is difficult to articulate has been inferred from its appearance in the Schoolmaster's book (**13**) in a list of words considered difficult to pronounce.[19] The list, however, comprises words that display no homogeneity except that they all are monosyllabic; κνάξ is preceded by στράγξ, which is indeed remarkable for the number of consonants and can thus be difficult to articulate, but is followed by φλοῦς, hardly a challenge. In fact, most words on the list would probably not be difficult to enunciate.[20] On the other hand, an isolated element of a sequence does not need to be hard for the entire utterance to be a tongue twister: it is not "Peter" or "Piper" by themselves that render "Peter Piper picked a peck of pickled pepper" etc. difficult. That is, even if κνάξ were easy, which I think it is, it could theoretically form part of a combination aimed at challenging one's ability to enunciate. It is just that there is no evidence that the perfect pangram beginning with κνάξ served that purpose.

To be sure, the sequence κναξζβιχθυπτησφλεγμοδρωψ is not easy to utter in one breath,[21] but once broken into elements, such as κνὰξ ζβὶ χθὺ πτὴς φλεγμὸ δρώψ or κνὰξ ζβὶ χθυπτὴς φλεγμὸ δρώψ, both well attested divisions (**1**, **2**, **3**, **11**), it becomes remarkably easy. That the pangram was conceived as consisting of the elements is in fact supported by the occurrences of κνάξ as a stand-alone 'word', as well as by word-divisions between other elements.

It is informative to compare Greek to modern examples of perfect (also called genuine) pangrams. In English, the most

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[19] Fournet, *RPhil* 74 (2000) 65.

[20] The list, as it survives, reads θήρ, πῦρ, πύξ, λάξ, χήν, σάρξ, αἴξ, λύγξ, στράγξ, κνάξ, φλοῦς, [– –] ῦς, κήρ, θίν, κλάγξ, ῥίν, πούς, χείρ (lines 27–37 in Guéraud/Jouguet)

[21] Cf. the discussion of clusters of consonants that are difficult to pronounce in Dionysius Hal. *Comp.* 22, to which I return below.

dexterous one, "squdgy fez, blank jimp, crwth vox," was composed by Claude E. Shannon, the famous mathematician and cryptographer.[22] In German, a perfect pangram (*echtes Pangramm*) seems possible only if vowels with umlauts are included, e.g. "Vogt Nyx: 'Büß du ja zwölf Qirsch, Kämpe!' "[23] These pangrams are not pleasant in sound, but they would hardly be considered a device to improve pronunciation. What they and, even more so, less successful examples reveal is painstaking effort that accompanied their creation. It is telling that the best specimen in English was created by a man known as "the father of information theory" and an avid fan of puzzles and games. It would be reasonable to expect that composition of Greek perfect pangrams required considerable effort, too, and that the results would probably be appreciated at least by those who gave it a try.

In search of meaning

Richard Bentley in his *Epistola ad Joannem Millium* (1733) imagined that Greek perfect pangrams were composed as a kind of game: "apparently it was once an amusing and childish computation; thus from twenty-four letters with each employed no more than once, they would make some barbaric and silly words, as long as it pleased." He went on to suggest that "later on they could show off their talent by thoroughly tracking down some meaning for these words, and one that was not even entirely strange and discordant, but obtained, to the extent possible, from what was at hand and credible."[24] The pur-

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[22] Friedrich L. Bauer, *Decrypted Secrets: Methods and Maxims of Cryptology* (Berlin 2007) 238.

[23] Other interesting examples with annotations and attributions can be found at http://faql.de/sonstiges.html#pangramme (accessed 15 Nov. 2016).

[24] Ed. A. Dyce, *The Works of Richard Bentley* II (London 1836) 239–365 (repr. *Epistola ad Joannem Millium* [Toronto 1962]), at 302: "Videlicet erat olim ridicula et puerilis ratio; ut ex quatuor et viginti literis, semel duntaxat positis singulis, barbara quaedam et infaceta verba conficerent, prout ciuque libitum fuerit … Postea certandum erat ingenio, ut sententiam istorum verborum aliquam omnibus vestigiis indagarent; non eam quidem omnino

pose of composition thus, Bentley suggests, was to put together a sequence of word-like elements which would be conducive to the assignment of meaning. That this assignment of meaning indeed took place is well attested by some literary sources, to which I now turn.

All three perfect pangrams are cited and discussed by Clement of Alexandria (**1**) in *Stromata* 5.8, which is devoted to the use of symbolism by poets and philosophers. In order of their appearance, they are:

> βέδυ ζὰψ χθὼμ πλῆκτρον σφίγξ[25]
> κνὰξ ζβὶ χθὺ πτὴς φλεγμὸ δρώψ
> μάρπτε σφὶγξ κλὼψ ζβυχθηδόν[26]

Clement takes for granted that pangrams are used in an educational context, but his interest lies in the meanings of the 'words' that comprise them and their symbolic or even mystical implications. He tells, on the authority of Apollodorus of Corcyra,[27] the story about the purification of the Milesians from the plague by Branchus, the priest of Apollo, who used laurel branches to sprinkle the crowd and appealed to the people to sing to Hecaergus and Hecaerga, i.e. Apollo and Artemis. To this the people responded by saying βέδυ, ζάψ, χθώμ, πλῆκ-

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alienam et absonam, sed a propinquo si fieri potuit, et verisimili petitam."

[25] The MS. (*Laur.* V 3, 11th c. = L) reads χθών, corrected by Nauck to χθώμ, since an assimilation of nu to mu is necessary for the sequence to be a perfect pangram; cf. Fournet, *RPhil* 74 (2000) 66 with n.20. The sequence is also attested in the Hermopolis papyrus (**7**), but it is not entirely clear whether nu or mu was written there (it almost looks like mu was written first, and pi was inscribed over its right-hand side, but the papyrus is abraded at this place). In the Bodleian MS. (**2**) it is written as χθώ (line 14) and χθών (line 15), but that manuscript is badly corrupted, cf. Callanan, *CQ* 45 (1995) 217–218. The sherd from Ephesos (**12**) preserves only the last six letters of this pangram.

[26] This perfect pangram has not been attested so far apart from Clement.

[27] Otherwise unknown; for attempts to identify him see Fournet, *RPhil* 74 (2000) 64 with n.12.

τρον, σφίγξ, κναξζβί, χθύπτης, φλεγμό, δρώψ.[28] Clement then supports this story with a reference to Callimachus' *Iambi*, in which Branchus purified the Ionians in a procedure that featured laurel branches and the uttering of spells (*Iamb*. 4.30–31, fr.194 Pf., κῆπος … δὶς ἢ τρὶς εἰπών; first published as *P. Oxy*. VII 1011). But although Callimachus mentions the spells, seemingly confirming the narrative of Apollodorus of Corcyra, his story contains no pangram-spell; nor is it likely that the spells were in the lost part of this or another poem, as it would hardly be possible to accommodate them in verse·.[29]

To elucidate the presumed spell in the story about Branchus and the plague, Clement proposes that κναξζβί means "the plague," as derived from gnawing (κναίειν) and destroying (διαφθείρειν), and θῦψαι,[30] which means, he says, to "inflame with a thunderbolt" (τὸ κεραυνῷ φλέξαι). He goes on to cite what he believes to be verses by the tragedian Thespis, which attest different meanings of the words in the κνάξ-pangram. Here is the passage, which has been subject to many corrections and changes:

> ἴδε σοι σπένδω κναξζβὶ τὸ λευκὸν
> ἀπὸ θηλαμόνων θλίψας κνακῶν·
> ἴδε σοι χθύπτην τυρὸν μίξας
> ἐρυθρῷ μελιτῷ, κατὰ σῶν, Πὰν
> δικέρως, τίθεμαι βωμῶν ἁγίων.
> ἴδε σοι Βρομίου [αἴθοπα] φλεγμὸν λείβω.

[28] The division κναξζβὶ χθύπτης is that of the MS. (L), and is, as I argue below, correct; most editors change it to κναξζβὶχ θύπτης to conform with Hesychius (**3**), cf. Fournet, *RPhil* 74 (2000) 73–74, and to reconcile with the etymology adduced by Clement, cf. Callanan, *CQ* 45 (1995) 219.

[29] Branchus was also the subject of Callimachus' poem in catalectic choriambic pentameters, of which only 13 verses survive (fr.229); it is sometimes considered *Iambus* 17. For a recent overview see S. Stephens, "Introduction," in *Brill's Companion to Callimachus* (Leiden 2011) 1–19, esp. 7–8; and for a detailed discussion, E. Lelli, *Callimaco. Giambi XIV–XVII* (Rome 2005), esp. 71–80.

[30] The MS. of Clement has διαφέρειν and θρύψαι. For detailed discussion of this passage see Callanan, *CQ* 45 (1995), esp. 222–224.

1 κναξζβὶ L, Merkelbach: κναξζβὶχ Stählin; [τὸ] secl. Toup   2 ἀπὸ L: γάλα corr. Nauck   3 χθύπτην L, θύπτην Salmasius   4 μέλιτι L, μελιτῷ Schwartz, μέλιτι transp. ante χθύπτην Nauck   6 αἴθοπα secl. Nauck.

Or, if one accepts Nauck's emendations:

ἴδε σοι σπένδω κναξζβὶ τὸ λευκὸν
γάλα θηλαμόνων θλίψας κνακῶν·
ἴδε σοι μέλιτι χθύπτην τυρὸν
μίξας ἐρυθρῷ κατὰ σῶν, Πὰν
δικέρως, τίθεμαι βωμῶν ἁγίων.
ἴδε σοι Βρομίου φλεγμὸν λείβω.

Nauck seems to be the only scholar to accept the manuscript reading of the first verse, where the majority correct κναξζβὶ τὸ λευκὸν to κναξζβὶ<χ> [τὸ] λευκὸν.[31] This correction, which reflects preference for the authority of Hesychius (**3**), who has ζαβίχ (for ζβίχ) and θύπτης, over that of the Bodleian passage (**2**), has in turn necessitated the deletion of the article for metrical reasons.[32] The Louvre tablet (**11**), which divides κναξ / ζβι / χθυ etc., provides further confirmation both of the readings in Clement and of Nauck's ingenuity.[33] As for Nauck's emendations, the correction of ἀπὸ to γάλα in 2 is attractive as it suggests equation of γάλα λευκόν to κναξζβί and opens up the possibility of treating the latter as two 'words', i.e. κνάξ and ζβί = "milk" and "white,"[34] while transposition in verses 3–4 allows one to keep μέλιτι, the correct form of the word used in

[31] R. Merkelbach, "Weiße κναξβι-Milch (zu Thespis 1 F 4 Snell)," *ZPE* 61 (1985) 293–296, like Nauck accepts the manuscript reading κναξβι, but excises the article in line 1.

[32] I.e., to ensure that the line scans as an anapest: ἴδε σοι σπένδω κναξζβὶ<χ> [τὸ] λευκὸν (˘ ˘ – – – – – [˘] – –), cf. Le Boulluec, *Clément d'Alexandrie* 188–189. For discussion of comparative values of the texts of Clement and Hesychius see Callanan, *CQ* 45 (1995), esp. 218–220.

[33] If κναξζβί remains in the text, the article τό that follows it does not hinder the meter: the verse is an anapestic dimeter (˘ ˘ – – – – ˘ ˘ – –), with a dactyl in the third foot, which is a common substitution.

[34] Cf. Merkelbach, *ZPE* 61 (1985), esp. 294 with n.7; also Luz, *Technopaignia* 115–119.

the manuscript tradition, in a metrically appropriate position.

The translation can be rendered approximately:

> Lo, I offer to you a libation of κναξζβί,
> white milk, having pressed it from the tawny nurses.
> Lo, to you, χθύπτην, cheese, with red honey
> having mixed, o double-horned Pan,
> I place it on your sacred altars.
> Lo, to you I pour as a libation φλεγμόν of Bromius.[35]

Clement rounds out his discussion by offering a symbolic inter-pretation of the entire sequence and an explanation for the word δρώψ, which is absent from the verses: Thespis "signifies, as I think, the soul's first milk-like nutriment of the four-and-twenty elements, after which solidified milk comes as food, and then lastly the sparkling wine, the blood of the vine of the λό-γος, the perfecting joy of education. And δρώψ is the operating (δραστήριος) λόγος, which, beginning with elementary training and advancing with the growth of man, incites and illuminates that man until he reaches the measure of maturity."[36]

Clement's interpretation of the sequence is in agreement with Hesychius (**3**), who glosses the words thus: κνάξ is "white milk," ζβίχ is "white," θύπτης is "cheese," φλεγμός is "blood," δρώψ is "man."[37] They fit perfectly, so much so in fact that one realizes that Hesychius derives his information from the pur-ported passage of Thespis and Clement's theological explica-tion of it. The question then is from where Clement derives the

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[35] The verses are sometimes assigned to Heraclides Ponticus: fr.181 Wehrli, followed by Merkelbach, *ZPE* 61 (1985) 293–296, and Fournet, *RPhil* 74 (2000) 61–82.

[36] Clem. Alex. *Strom.* 5.8.48.8–9: αἰνίσσεται, οἶμαι, τὴν ἐκ τῶν τεσσάρων καὶ εἴκοσι στοιχείων ψυχῆς γαλακτώδη πρώτην τροφήν, μεθ' ἣν ἤδη πε-πηγὸς γάλα τὸ βρῶμα, τελευταῖον δὲ αἷμα ἀμπέλου τοῦ λόγου τὸν "αἴθοπα οἶνον," τὴν τελειοῦσαν τῆς ἀγωγῆς εὐφροσύνην, διδάσκει. δρὼψ δὲ ὁ λόγος ὁ δραστήριος, ὁ ἐκ κατηχήσεως τῆς πρώτης εἰς αὔξησιν ἀνδρός, "εἰς μέτρον ἡλικίας," ἐκφλέγων καὶ ἐκφωτίζων τὸν ἄνθρωπον.

[37] κ 3086 κνάξ· γάλα λευκόν, ζ 85 ζάβιχ (lege ζβίχ)· λευκόν, θ 920 θύπτης· ὁ τυρός, φ 585 φλεγμός· τὸ αἷμα, δ 2468 δρώψ· ἄνθρωπος.

meanings with which he explicates the Thespis fragment. Reinhold Merkelbach has argued convincingly that they come from the fragment itself: the quoted verses describe a sacrifice to Pan of milk, cheese, and wine, with κναξζβί, χθύπτης, and φλεγμός in apposition to each respectively.[38] It follows that, otherwise, they should have no meaning, and in fact a Neo-platonist and scholar of Aristotle, Ammonius, lists κνάξ along with βλίτυρι and σκινδαψός as examples of ἄσημοι φωναί, "meaningless words" (**4**), in which he is followed by his pupil Olympiodorus (**5**). As to the question why the verses attributed by Clement to Thespis were composed, Merkelbach suggests that they were meant as a joke built upon an elementary school exercise that employed all letters of the alphabet in the sequence κναξζβιχθυπτησφλεγμοδρωψ. But what kind of exercise could this be and why would it be so widely known?

Theological elaborations aside, Clement's discussion brings out two things one can do with the κνάξ-pangram: invoke it in the context of a ritual and ascertain meanings for its elements. Clement himself adduces two sets of meanings, one of which is drawn from a story by Apollodorus of Corcyra and based on etymology and the other from the passage ascribed to Thespis. These two sets of meanings cannot be reconciled with each other, and remarkably there survives evidence for a third set. In *Epistola ad Joannem Millium*,[39] Bentley quotes a Greek passage attributed to Porphyry that contains interpretations of two pangrams, which Bentley claims to have found in an Oxford manuscript. Bentley's transcription was the only source of the passage, until Christopher Callanan came across it again while working on *Bodl.gr.Barocci* 50, a tenth-century manuscript containing mostly grammatical and lexicographical works, followed by miscellanea; the passage quoted by Bentley is on ff. 353ᵛ.15–354ʳ.13 (**2**). I reproduce the part of the text that deals with the κνάξ-pangram (the rest of the passage is devoted to

[38] Merkelbach, *ZPE* 61 (1985) 293–296.

[39] *Epistola* 303–304.

the βέδυ-pangram), mostly following Callanan's edition and using his designation of the manuscript as O:

Πορφυρίου φιλοσόφου

περὶ τοῦ κνάξ· ζβί· χθύ· πτής· φλεγμῶ· δρόψ· ἑρμενεία

ἐν Δέλφοις εἰς τὸν ναὸν ἐπιγέγραπται τράγος ἰχθύει ἐπὶ δελφῖνος

4 ἐπικείμενος· κνὰξ μὲν γάρ ἐστιν ὁ τράγος κατὰ ἀποκοπὴν τῶν
στοιχείων τοῦ κῶς, ἢ καὶ πάλιν ἀφαιρέσει τοῦ ξ· κνάκον γὰρ
καλεῖται, ὡς καὶ Θεόκριτος ἐν βουκόλοις λέγει, οἷον τράγος
καὶ ἰχθὺς ὁ μὲν φλεγόμενος †ὁ δὲ δρὸν ὄψον†

8 λέγει δὲ ὅτι ὁ τράγος φλεγόμενός ἐστιν πάντοτε ὑπὸ λαγνίας,
ὅτι ἐάν τις τὰς ῥῖνας αὐτοῦ ἀποσφαλίσει, διὰ τῶν κεράτων
ἀναπνεῖ. ἔχει δὲ καὶ ἑτέραν ἑρμενείαν οὕτως· τὸ κνὰξ ζβὶ γάλα
ἐστὶν τὸ δὲ χθὺ πτής τυρός· δρὸψ ἄνθρωπος· δρῶπες γὰρ οἱ

12 ἄνθρωποι λέγονται.

2 πτίς O   lege φλεγμό· δρώψ   3 lege ἰχθύι: ἰχθύς Callanan   5 κων
Bentley, Callanan   ἢ O, del. Bentley   ἀφαιρέσει Callanan: ἀφαίρεσις
O, ἀφαίρεσιν (lege πρόσθεσιν) Bentley   κνάκων Bentley coll. Theocr. *Id.*
3.5   8 lege λαγνείας   9 ἀπασφαλίσῃ Bentley, ἀποσφαλίσῃ Callanan
10 τῶ O   κναξζβὶ, Bentley, Callanan   11 χθὺ πτίς O, χθυπτής Bentley,
Callanan   lege δρώψ.

Porphyry the Philosopher:

On the Interpretation of κνάξ, ζβί, χθύ, πτής, φλεγμό, δρώψ[40]

At Delphi, in the temple, there is a drawing of a goat on a fish upon a dolphin. For κνάξ is a goat (τράγος) by taking away the letters κως [read: κων], or, in turn, by removal of the letter ξ. For it is called κνακον [read: κνάκων], as indeed Theocritus says in his *Idylls*,[41] that is, "goat" (τράγος) and "fish" (ἰχθύς), the first blazing, †… "cooked food" (ὄψον).†

And he says that a goat is always ablaze when in fervor of coition, because if one fastens shut its nostrils, it breathes through the horns.[42] There is also another interpretation: κνὰξ

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[40] That the correct spelling should be φλεγμό, δρώψ is confirmed by documentary attestations (**10**, **11**, **12**) as well as Clement (**1**); Callanan (220) prefers to remain undecided on this point.

[41] Theocr. 3.5, καὶ τὸν ἐνόρχαν / τὸν Λιβυκὸν κνάκωνα φυλάσσεο, μή τι κορύψῃ ("and beware of the goat, that Libyan tawny, lest he butt you").

[42] Bentley comments that "horns" should be emended to "ears," and adduces a passage of Varro affirming that goats breathe through the ears (*RR*

ζβί is milk, χθὺ πτής is cheese, and δρώψ is a man, for men are called δρῶπες.[43]

While it is impossible to unravel this passage, which is badly corrupt and lacunose, Callanan argues convincingly that the first six lines of the text, i.e., up to οἷον τράγος, can be made some sense of without the drastic corrections proposed by Bentley. What was meant in the original passage was perhaps something to the effect that κνάξ is like the word "goat" because without ξ it is reminiscent of the word κνάκων, "goat," minus its ending in -κων.[44] In other words, there is a superficial resemblance between κνάξ and κνάκων that can be made clear by their mechanical transformation. As for the interpretation of the passage, Callanan argues that the pictorial representation referred to in lines 3–4 may be related in some way to astrology, since the constellation Capricorn is often represented as a mixture of a goat and fish.[45]

The Oxford passage, despite its opaqueness, provides a few pieces of information on the κνάξ-pangram. First, it divides the pangram into smaller elements than are found in Clement and the passages he cites; second, by furnishing yet another set of meanings for these elements it suggests that not a fixed meaning but the possibility of a meaning was a consideration in the

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2.3.5, who in turn refers to the authority of Archelaus); for a discussion of further evidence for the ancients' beliefs on goat's breathing see Callanan, *CQ* 45 (1995) 222–223.

[43] Luz, *Technopaignia* 124 n.165, gives a German and Fournet, *RPhil* 74 ((2000) 74–75, a French translation of the passage as cited in Bentley; both scholars appear to have been unaware of Callanan's rediscovery of the MS.

[44] Callanan, *CQ* 45 (1995) 222, translates: "For the he-goat is κνάξ, by dropping the letters κων <from κνάκων>, or, going in the other direction, also by elimination of ξ <from κνάξ, and of course the subsequent addition of the just-mentioned κων>."

[45] Consequently, he argues (221) for reading τράγος ἰχθύς in line 3 and interprets the two words as referring to a cross between goat and fish and "forming together the preliminary stage of what could become a compound word." I am inclined to keep the manuscript reading, for, even if a mixed creature is meant, it could have been described as "a goat added to a fish."

composition and combination of the elements. Further, it seems to place a4 drawing associated with inscribed or represented elements of the sequence in a sanctuary context, Delphi. This may imply religious connotations, but perhaps also a perception of the pangram as something remarkable or precious. And finally, the discussion of the elements of the pangram as associated with a drawing suggests a spatial arrangement of its elements. As chance would have it, spatial representation is attested also in a tablet from Egypt.

Visualizing the pangram

In 1971 Bernard Boyaval published several wooden tablets found in Antinopolis at the beginning of the twentieth century and kept in the Louvre. One tablet, AF 1193 (**11**), appeared to contain nicely written letters in no apparent order. At the time, the tablet was missing a part, which was located only after Boyaval's publication. On the side of the reconstructed tablet designated the verso, Brashear recognized "ein Beispiel eines Ganz-Alphabet Spiels," κναξζβιχθυπτησφλεγμοδρωψ, and transcribed it thus:[46]

	κ	ζ			φ	γ	δ
	ν	β	χ	π	λ	μ	ρ
	α	ι	θ	τ	ε	ο	[ω]
	ξ		υ	η			ψ
				σ			

Brashear, however, did not discern fully the arrangement of the pangram: he printed the third and fourth columns a full row lower in relation to the others, the reason surely being that letters χ and π are inscribed lower than the other letters in the first row because of the holes for fastening in the upper part of the tablet, which the writer was forced to avoid (see *fig.* 2).[47] In

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[46] W. Brashear, "Lesefrüchte," *ZPE* 50 (1983) 97–107, at 98.

[47] Callanan, *CQ* 45 (1995) 219, reproduces Brashear's arrangement; cf. also Luz, *Technopaignia* 132 with n.194. Brashear provides no image, while the photo in the ed. pr. was made before the upper part of the tablet containing the uppermost row of letters was discovered in the museum and joined to the lower part.

subsequent rows, letters of the third and fourth columns are aligned with the letters in other columns, so that the following design emerges:[48]

Ᵽ	K	Z	X	Π	Φ	Γ	Δ
	N	B	Θ	T	Λ	M	P
	A	I	Y	H	E	O	Ω
	Ξ		Σ				Ψ	μη(νὸς)· Φα$\underline{μ}$(ενὼ)θ
								$\underline{η}$

The recto side of the tablet is also inscribed with a table (*fig.* 3):

Fig. 3. Wooden tablet from Antinopolis, 5th–6th c., recto
(Louvre inv. AF 1193r)
Photograph ©Musée du Louvre/Georges Poncet

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[48] The tablet is dated Phamenoth 8 in a small cursive script. Dating school tablets was not uncommon, cf. P. van Minnen, "A Late Antique Schooltablet at Duke University," *ZPE* 106 (1995) 175–178. A date is also given on another tablet in the group published by Boyaval (no. 1, Louvre inv. MND 562c); that tablet has a list of syllables, indicating that it too comes from an educational environment.

Α	Ρ	Κ	Γ	Τ	Μ
Ε	Φ	Ξ	Η	Ψ	Π
Ι	Β	Σ	Λ	Δ	Υ
Ν	Ζ	Χ	Ο	Θ	Ω

I discuss the arrangement of the recto in the Appendix. For the moment it suffices to note that the design in which letters of the alphabet, or their *permutatio,* are written in a table with columns of equal length is quite common.

The tabular form of the κνάξ-pangram is striking at first sight. It comprises rows and columns of different length, and yet it is nicely symmetrical: the first, fourth, and seventh columns contain four letters each, with two three-letter columns placed on each side of the central axis formed by the fourth column. Another salient point in the design is that all vowels of the alphabet are lined up in the third row of the table, which, reading from left to right, starts with alpha and ends with omega, the first and last letters of the alphabet. Within this row, first come the three δίχρονα, to use the terminology of Greek grammarians, the vowels that could be either short or long, followed by two pairs of βραχέα and μακρά, letters indicating the same sound of different lengths (ē and ĕ, ŏ and ō).[49] The fourth row contains the three sigmatic letters, ξ, σ, ψ. The remaining fourteen consonants are divided between the first two rows so that the first consists of seven mutes, ἄφωνα, κ ζ χ π φ γ δ, and the second has all four 'unchangeable' or 'liquid' consonants, ἀμετάβολα or ὑγρά in the terminology employed by Dionysius Thrax, ν λ μ ρ. It also contains the remaining three mute consonants, β θ τ.

While the arrangement displays knowledge of Greek phonetic studies as manifested in the works of Dionysius of Halicarnassus or Dionysius Thrax, it does not completely comply with their classification of letters and sounds. Not only are three mutes included with the four liquids in the second row,

[49] See the discussions of vowels in Dion. Hal. *Comp.* 14 and Dion. Thrax *Ars gram.* 10.

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but also ζ is placed in the first row with six mutes. In the grammarians, ζ is usually grouped with the liquids and sigmatic letters among the semi-vowels, ἡμίφωνα, and then, because it consists of σ + δ, with ξ and ψ among the doubles, διπλᾶ.[50] The arrangement of the tablet, although undoubtedly based on theories similar to the one in Dionysius of Halicarnassus, reflects also practical considerations in the combinations of letters. Thus, the first two consonants in each column form sequences acceptable in Greek phonetics, and, for the most part, such that can begin a word. For example, many words begin with χθ, but none with θχ,[51] nor is the sequence θχ possible; the same is true for the combination of π and τ, and while ζβ is rare in any position and attested only in dialectal forms, βζ is outright impossible. The remaining four letters in the second row are liquids; their placement in the second row, i.e. below the mutes of the first, illustrates the principle of Greek phonetics expressed by Dionysius of Halicarnassus: "it is not possible for the semivowels to precede the mutes," i.e. in the same syllable,[52] and by extension, to begin a word.

As for letters that can terminate a Greek word, Dionysius Thrax lists the possible final elements by categories of words: "the final elements of masculine … nouns, in the nominative case and singular, are five, ν ξ ρ σ ψ, … of the feminine, eight, α η ω ν ξ ρ σ ψ, … of the neuter, six, α ι ν ρ σ υ, … some also add ο, as in ἄλλο. Of the duals, there are three, α ε ω, … of the plurals, four, ι σ α η."[53] In the tablet, the sigmatic letters are

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[50] Dion. Hal. *Comp.* 14; Dion. Thrax *Ars gram.* 11, 14.

[51] It is on this basis that Merkelbach, *ZPE* (1985) 293 with n.4, defends the 'word-division' κναξβὶ χθυπτής.

[52] *Comp.* 22, οὐδενὸς δὲ πέφυκε προτάττεσθαι τῶν ἀφώνων τὰ ἡμίφωνα <κατὰ μίαν συλλαβήν>, and cf. οὐ γὰρ πέφυκε κατὰ μίαν συλλαβὴν τοῦ χ προτάττεσθαι τὸ ν, "it is not possible for ν to precede χ in one syllable."

[53] Dion. Thrax *Comp.* 15–16: τελικὰ ἀρσενικῶν ὀνομάτων † ἀνεπεκτάτων κατ' εὐθεῖαν καὶ ἑνικὴν πτῶσιν στοιχεῖά ἐστι πέντε· ν ξ ρ σ ψ, … θηλυκῶν δὲ ὀκτώ· α η ω ν ξ ρ σ ψ, … οὐδετέρων δὲ ἕξ· α ι ν ρ σ υ, … τινὲς δὲ προστιθέασι καὶ τὸ ο, οἷον ἄλλο. δυϊκῶν δὲ τρία· α ε ω, … πληθυντικῶν δὲ
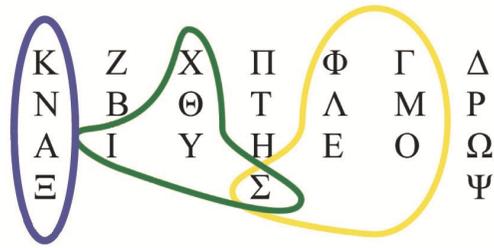
placed in the final fourth row, while the positioning of other letters that can terminate a word also does not seem to be accidental. Here I render the τελικὰ στοιχεῖα, "final elements," in italics and bold to emphasize how contrived the design of the pangram is:

Κ	Ζ	Χ	Π	Φ	Γ	Δ
N	Β	Θ	Τ	Λ	Μ	*P*
A	*I*	*Y*	*H*	*E*	*O*	*Ω*
Ξ			*Σ*			*Ψ*

The phonetic principles of Greek upon which this arrangement is based could in turn be illustrated with the help of the tablet. Using it, one could perhaps further explain these principles by composing units that are phonetically possible and thus pronounceable. These units may be meaningless, but they look like words and thus are both conducive to assignment of meanings and fairly easy to remember.

Although the complete tabular representation of the pangram survives only on the Louvre tablet, hints to it can perhaps be detected in the passage attributed to Porphyry in the Bodleian manuscript (**2**) and in the graffito found in Lattes (**6**). The Porphyry passage seems to describe a pictorial composition that is meant as a visual presentation of the pangram, in which a goat (τράγος which is equated with the word κνάξ) is said to be upon a fish, ἰχθύς. The word ἰχθύς is nowhere in the pangram if it is written out in a line, i.e. as κναξζβιχθυπτησφλεγμοδρωψ, or as a linear sequence of the elements, κνὰξ ζβὶ χθὺ πτὴς φλεγμὸ δρώψ, but one can discern it in the tabular format, as in the drawing below. The word κνάξ, to the left of it, perhaps can then be seen as being upon it or attached to it. On the right-hand side, φλεγμός can be read, which is perhaps what is referred to by the "blazing" of the goat in the passage. The combinations forming these readings could be schematically represented thus:

τέσσαρα· ι σ α η.

The sherd from Lattes preserves only the first four letters of the alphabet and of the pangram, both apparently written in line, but on the reverse side a grid is scratched (*fig.* 1). One wonders whether the person who scratched the letters on one side of the sherd may have had some spatial or tabular arrangement in mind for which he, or she, has incised the grid.

While these two instances are conjectural, it does seem to be the case that the design of the perfect pangram as preserved on the Louvre tablet rendered it conducive to various manipulations, whether visual or linguistic. Furthermore, in the absence of meanings for the parts and of a metrical pattern for the whole of the pangram, its visualization may have also served as a mnemonic device. Reproducing the pangram in the tabular form from memory is actually surprisingly easy.

The question that presents itself is in what environment and when did the κνάξ-pangram arise. The earliest attestation is of the element κνάξ alone, not as part of the pangram; it occurs in the Schoolmaster's book, a papyrus dated to the third century B.C. (**13**). Although the sherd from Lattes (**6**), which is datable to the late third century B.C., preserves only these letters, κναξ, the break on the right-hand side makes it probable that the line continued, and likely with the letters of the pangram. The geographic range of these two pieces of evidence is from Egypt (possibly the Arsinoite, **13**) to the northern shore of the western Mediterranean (Lattara, **6**). The indisputably earliest witnesses to the letters of the entire pangram (**7** and **12**) date no later than the first century of the Common Era and come from (probably) Hermopolis in Egypt (**7**) and Ephesos in Asia Minor (**12**). The evidence preserved in literary sources allows of no more precise dating than the time of their composition as the

terminus ante quem, ca. A.D. 200 for the *Stromata* of Clement.

Since the element κνάξ by itself seems to have no meaning, nor to present any particular difficulty in pronunciation, it is plausible that its appearance in the Schoolmaster's book (**13**) implies that its writer was familiar with the pangram. The small sherd from Lattes (**6**) could hardly be meant as an exercise in reading strange words; the juxtaposition of the surviving letters of κνάξ with the first four letters of the alphabet, all neatly incised on a small ceramic fragment, which was carefully chosen for its flatness and rectangular shape, rather suggests that it was meant as an object to display the alphabet and the perfect pangram. If so, then the origin of the pangram should be placed perhaps in the middle of the third century B.C. at the latest, the period which Christine Luz describes as the *Blütezeit* of the art of *technopaignia*.[54] It is no less possible, though, to imagine it a century or so earlier, with the developed interest in phonetics attested as early as the discussion of sounds in Plato's *Cratylus* (426C–427C) and the propensity for visual effects of writing witnessed by the acrostics associated with the tragedian Chaeremon or the orator Aeschines.[55]

Another question is whether the tabular design of the κνάξ-pangram was its original or a later arrangement: the Louvre tablet that displays it dates to the fifth century; the passage in the Bodleian manuscript that may conform to it is undatable in its extant form, even if it ultimately derives from an epitome of a work of Porphyry; other documentary evidence provides no certain indication of tabular arrangement. Yet it is precisely the intricate properties revealed by the tabular arrangement that

[54] Luz, *Technopaignia* 368.

[55] Fournet, *RPhil* 74 (2000) 64 with n.14, who is inclined to accept that the verses ascribed to Thespis were authored by Heraclides Ponticus, believes that the pangram must have been known already in the fourth century B.C.; Merkelbach, *ZPE* (1985) 294, who also accepts the assignment of the Thespis verses to Heraclides, would take the composition of the pangram even earlier, suggesting that it is as old as the Milesian alphabet of 24 letters.

may give weight to its being the original design, concurrent with the introduction of the pangram. This scenario, in which letters of the alphabet were assembled in units and arranged so as to present contrived, non-accidental combinations, can account better for the longevity of the κνάξ-pangram, as well as for the fascination of the ancient sources with it, than supposing that the pangram was repeated over a long period of time until it was noticed that it could be arranged in a remarkably meaningful tabular form.

Concluding remarks

Whether the other two perfect pangrams, βέδυ ζὰψ χθὼμ πλῆκτρον σφίγξ and μάρπτε σφὶγξ κλὼψ ζβυχθηδόν, come from the same environment as the κνάξ-pangram cannot be ascertained, but this seems possible. They feature more actual words and can be interpreted as at least partially making sense, e.g. "Sphinx, catch! Thief! ζβυχθηδόν," where the last 'word' has an adverbial shape. Curiously, despite its apparently more concrete sense, this perfect pangram is not attested outside the discussion in Clement, whereas the κνάξ-pangram, with its meaningless 'words', is by far the most popular. Again, one wonders whether it is the construction of the pangram as a felicitous scheme reflecting properties of the Greek language that has ensured its popularity throughout the Greek-speaking world. And as with magic squares or isopsephic inferences, the tabular design of the pangram may have contributed to the perception that it possessed supernatural qualities or broad ritual or magic powers. This would explain the apparent religious connotations of the κνάξ-pangram in the story attributed to Apollodorus of Corcyra, as well as the sanctuary context in the passage cited in the Bodleian manuscript.

Would all those who over the centuries wrote down the κνάξ-pangram be aware of the various features that its tabular arrangement could yield? Probably not, and while the writer of the Louvre tablet likely was aware of this, for others the sequence may have been just a combination of all the letters of the alphabet in an order that, when split into word-like elements, was relatively easy to pronounce and remember. It

was used in an educational environment, as both Clement and some documentary evidence attest, but to what end is difficult to say—and it would probably depend on the teacher. It could serve as an illustration of the peculiarities of Greek phonetics and principles of word-formation, but perhaps also as a scrambled alphabet to help a student master letters in an un-accustomed order.[56] Outside of school, it may have been a handy device for an exercise in calligraphy (**8** and **14**?);[57] it may also have been viewed as a magic spell with apotropaic function (**9** and **10**). Examination of the material evidence, that is, the objects inscribed with the κνάξ-pangram, has revealed a greater variety of practices associated with it than any study of literary sources alone could have afforded. What is more, ob-jects traditionally treated as representative of the earliest and lowest stages of ancient education, as first steps in reading or writing—the *abc*'s, turn out on closer analysis to reflect the ancients' sophisticated interest in properties of sounds and letters. They also make ancient education so much more in-teresting.

APPENDIX: ALPHABETIC TABLES

Although we tend to conceive of an alphabet as a linear sequence of letters, in the Greco-Roman world it was not infrequently written out in tabular form with letters either in the regular alphabetic order or with the order transformed in accordance with one of a few prin-ciples (*permutatio*). The most common tabular presentation of the alphabet[58] has it inscribed in six columns of four letters each:

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[56] For the latter see most recently Johnson, in *Companion to Ancient Edu-cation* 141–142 with further bibliography; also van Minnen, *ZPE* 106 (1995) 175–178.

[57] See esp. Fournet's discussion of the of alphabetic verses and various pangrams in Late Antique scriptoria: *P.Pintaudi* pp.263–265.

[58] Attestations of this design include a column of blue marble from Sparta (H. J. W. Tillyard, "Laconia: II. Excavations at Sparta, 1906," *BSA* 12 [1905/6] 476, no. 36 = *IG* V.1 365); a wooden tablet in Leiden (TM 100127 = LDAB 10766, 2nd c.); fragments of a wooden tablet in the British Museum (TM 64098 = LDAB 5316, 2nd –3rd c.); a Greek-Coptic limestone

↓	α	ε	ι	ν	ρ	φ
	β	ζ	κ	ξ	σ	χ
	γ	η	λ	ο	τ	ψ
	δ	θ	μ	π	υ	ω

There are examples, in which the same arrangement (letters grouped by four in six units) is to be read horizontally, by rows:[59]

→	α	β	γ	δ
	ε	ζ	η	θ
	ι	κ	λ	μ
	ν	ξ	ο	π
	ρ	σ	τ	υ
	φ	χ	ψ	ω

Now, if one reads the letters horizontally in the first table or vertically in the second, he finds the next letter four removed from the preceding, that is, if positional numbers are assigned to letters, α (=1) is followed by ε (= 5), then ι (= 9), ν (= 13), ρ (= 17), φ (= 21); and then starting again from β (= 2) and proceeding in the same way to χ (= 22); then from γ (= 3) to ψ (= 23); and from δ (= 4) to ω (= 24). The resulting anagram can then be arranged in further ways so that the organizing principle of the *permutatio*, namely of recording every fourth letter, is not immediately apparent.[60] For example, a page from a schoolbook in the Vienna collection[61] has the every-fourth-letter anagram inscribed in three rows, eight letters to each row:

→	1	Ⲣ̄	α	ε	ι	ν	ρ	φ	β	ζ
			κ	ξ	σ	χ	γ	η	λ	ο
			τ	ψ	δ	θ	μ	π	υ	ω

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ostracon also in the British Museum (TM 65430 = LDAB 6677, 7th–8th c.).

[59] Brashear, *ZPE* 50 (1983) 99.

[60] Cf. van Minnen, *ZPE* 106 (1995) 175–178, who discusses the principle in the edition of a school tablet that preserves a slightly unsuccessful attempt at reproducing this kind of alphabetic anagram backwards, i.e. starting with ω and υ, and in three columns.

[61] P. Sanz, *MPER* N.S. IV 24 = TM 62056 = LDAB 3215 = P.Vind. inv. 29274, Arsinoite, 4th–5th c., page 14 = fol. VIIr and page 13 = fol. VIIv.

Immediately below and continuing on the back of the sheet, another alphabetic anagram is written:

    4   ⳨   αω   βψ   γχ   δφ
                        ευ   ζτ   ησ   θρ[62]
    p.13 (fol. VIIᵛ)   ι⟦φ⟧π κο   λξ   μ
                        ν[63]

        6: π is written over φ.

Here the outer letters on both ends of the alphabet are paired, with the first and last combined (αω), then the second and second-to-last (βψ), the third and third-to-last (γχ), and so on until μ and ν meet in the middle of the alphabet. The original editor prints letters as paired in lines 1, 4, 5, and 6 (= p.13, line 1), but variously grouped in lines 2 and 3.[64] H. Harrauer and P. Sijpesteijn (*MPER* N.S. IV p.26) reproduce page 14 of the notebook and render all letters as grouped in pairs; examination of the papyrus image suggests to me that intentional pairing is carried out only in lines 3 to 6.

To illustrate the principles according to which letters are ordered, Harrauer and Sijpesteijn assign positional number to each letter;[65] following their lead, it is possible to render the second anagram thus:

    ⳨   αω   βψ   γχ   δφ   1 + 24   2 + 23   3 + 22   4 + 21
         ευ   ζτ   ησ   θρ   5 + 20   6 + 19   7 + 18   8 + 17
         ιπ   κο   λξ   μν   9 + 16   10 + 15   11 + 14   12 + 13

One immediately notices that the sum of positional values of each pair of letters is 25. Should one want to calculate the sum of positional values of all letters of the Greek alphabet, i.e. of numbers from 1 through 24, pairing letters would be of great help. For, just as

[62] Sanz, *MPER* N.S. IV 24, followed by Harrauer and Sijpesteijn in MPER N.S. XV p.26, prints a staurogram on a separate line following line 5; examination of the image does not confirm it, nor should one expect to find it there since a staurogram is used in this schoolbook to mark the beginning of an entity, and none begins here.

[63] The letter ν must not have fit at the end of the line and was written below it.

[64] Sanz, *MPER* N.S. IV 24, transcribes lines 2 and 3 on p.14 as κξ σχγηλο / τψ δθμπυω.

[65] I thank Prof. Hermann Harrauer for discussing this issue with me *per ep*.

young Carl Friedrich Gauss quickly summed all numbers from 1 to 100 in response to his teacher's challenge,[66] one can easily add numbers 1 to 24 by multiplying the sum of each pair (25) by the number of such pairs (12), arriving at the total of 300.

This is not to say the anagram implies that the Greeks used a separate numeral system; the system common at the time made use of the Greek alphabet with three additional letters as symbols representing ones from 1 to 9 (α to θ), tens from 10 to 90 (ι to ϙ), and hundreds from 100 to 900 (ρ to ϡ). However, it would perhaps not escape attention of those who found joy in looking for the principles of arrangement of the alphabet, that the sequence of numbers from 1 to 24, that is, of positional values of letters from α to ω, offers fascinating possibilities. Besides the one just discussed, more could be drawn from the every-fourth-letter anagram; taken as numbers, the letters would then form four arithmetic progressions, six members each, all with the common difference of 4. They can then be ar-ranged in such a way that various patterns emerge.

The anagram inscribed on the recto of the Louvre tablet (**11**), the verso of which bears the κνάξ-pangram, might be case in point (*fig.* 3). Brashear[67] was the first to recognize that the letters are not random but arranged in the every-fourth-letter order:

↓	α ρ κ γ τ μ	1	17	10	3	19	12
	ε φ ξ η ψ π	5	21	14	7	23	16
	ι β σ λ δ υ	9	2	18	11	4	20
	ν ζ χ ο θ ω	13	6	22	15	8	24

If letters are assigned their positional values from 1 to 24, several patterns can be observed. For example, in each column the sum of the first and fourth item will be the same as that of the second and third (e.g. 1 + 13 = 5 + 9; 17 + 6 = 2 + 21), and thus the sum of the two inside rows (2 and 3) will be the same as that of the outside ones (1 and 4), both amounting to 150; the sum of numbers in col. 1 and col. 6 will be the same as that of col. 2 and col. 5, and as that of col. 3

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[66] 134 retellings of this anecdote have been collected and made accessible by Brian Hayes, the senior writer for *American Scientist,* at http://bit-player.org/wp-content/extras/gaussfiles/gauss-snippets.html (accessed 19 Nov. 2016).

[67] Brashear, *ZPE* 50 (1983) 98–99.

and col. 4, all of which amount to 100; and the list can be continued.

If positional values are assigned to the letters in the table representing the κνάξ-pangram (**11**), the sums of numbers in the first and second rows would be equal $(10 + 6 + 22 + 16 + 21 + 3 + 4 = 82$ and $13 + 2 + 8 + 19 + 11 + 12 + 17 = 82)$. Would this be noticed, if accidental,[68] or could this be an additional consideration in the arrangement of the letters of the pangram in this design, I would hesitate to conclude. But it would not be surprising if the possibilities offered by the assignment of positional values to the letters of the alphabet arranged in certain anagrams were appreciated.[69]

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[68] The probability that this is due to a coincidence is approximately 3%. I am indebted to Prof. Ivan Soprunov of Cleveland State University for determining this value.