Edited by Richard Dumbrill

Prima la musica e poi le parole

Proceedings of the International Conference of Near Eastern Archaeomusicology

ICONEA 2009 - 2010

Held at the Université de la Sorbonne, November 2009
and at
Senate House, School of Musical Research
University of London, December 2010

A Publication of ICONEA
The International Conference of Near Eastern Archaeomusicology
Institute of Musical Research
School of Advanced Study
University of London
Co-Published by

gorgias press

Co-Published by Gorgias Press LLC
180 Centennial Avenue
Piscataway, NJ 08854
USA
Internet: www.gorgiaspress.com
Email: helpdesk@gorgiaspress.com

ISBN 978-1-4632-0182-1

This volume is printed on acid-free paper that meets the American National Standard
for Permanence of paper for Printed Library Materials.
Printed in the United States of America

ICONEA 2009-2010
Table of Contents

EGYPTIAN FRACTIONS AND THE ANCIENT SCIENCE OF HARMONICS
Leon Crickmore p.1

HAND POSITION OF MUSICIANS BEFORE AND AFTER THE HYKSOS KINGS
Magdalena Kuhn p.11

SUMMON THE GODS AND THE PEOPLE TO THE SOUND OF THE CONCH
Elynn Gorris and Wim Verhulst p.21

SINGERS, MUSICIANS AND THEIR MOBILITY IN UR III PERIOD CUNEIFORM TEXTS
Regine Pruzsinszky p.31

ON THE MANIPULATION OF THE PLANETS BY THE LYRE PLAYER IN A 'WINE SONG' BY KHAMIS BAR QARDAḤE
Siam Bhayro p.41

DRUMS IN THE LATE XVIIIth DYNASTIES OF EGYPT
Lise Manniche p.47

MUSIC IN THE SYRIAN CITY OF EBLA IN THE LATE THIRD MILLENNIUM B.C.
Theo J.H. Krispijn p.55

PYTHAGORAS, THE ORIGINS OF MUSICAL MODI AND THE DACTYLS
Peter Strauven & Jan M.F. Van Reeth p.63

EGYPTIAN CONNECTIONS: NARMER INSCRIPTIONS AS SUMERIAN MUSICOLOGY
Ernest McClain p.73

MUSIC THEORISM IN THE ANCIENT WORLD
Richard Dumbrill p.107

THE EPISTEMOLOGICAL FRAMEWORK OF MUSICOLOGY
Bruno de Florence p.135

DANCE IN IRON AGE ISRAEL/PALESTINE 1200 - 600 B.C. ARCHAEOLOGICAL SOURCES AND GLYPTIC ART
Bathyia Schachter p.143

RECONSTRUCTING THE VOICE OF KING DAVID'S HARPS
Max Stern p.161

MUSIC THEORISM IN THE ANCIENT WORLD

Richard Dumbrill

Theorism[1] *is a conscious state which came as one of many consequences of literacy. This led to empiricism, to rationalism, to epistemology and finally materialised as theory as we understand it today. In the present paper I shall demonstrate how this concept shaped the theory of music in the Ancient World and how it influenced our own perception of theory.*

Part One:
1 Introduction

Preliteracy would have been the scene of isolated forms of theorism. Archaeology supports this postulation with the discovery of markers[2] (fig. 1) of different types and media. These would not have been intended for sharing among a group but would have been restricted to the usage of one individual, or to the usage of a few initiated members of a same group. Thus these attempts cannot be construed as empirical forms of theorism, the purpose of which being the propagation of concepts and not cryptic usage for the benefit of one or of a few isolated individuals. However, this might have contributed to the development of the concept.

Fig. 1. Ishango bone, obv. and rev., from the Congo. Photograph by the Science Museum, Brussels.

1.1 The setting

Some of the early inhabitants of southern Mesopotamia would have been migrants adding to the autochthonous and probably mainly Semitic population. There, they became agriculturists, raised cattle having landed at the right place at the right time and with the right circumstances of their development. Old nomadic endogamy was replaced by new sedentary exogamy which, as a consequence, contributed to the spreading of the male's language and to the assimilation of some of the female's in their own, but also and more importantly, to the assimilation and the spreading of each others' concepts, or to the suppression of one to the advantage of the other at levels which may be partially understood from the iconography of the myth and of the religion as well as from the earliest form of the written word.[3] But it is contended that as soon as common writing systems of numbers, of objects and of ideas were devised and shared by groups, that the necessity of writing down all that surrounded became a compulsion and ended up as the responsibility of a shaman who later rose to scribal status. Taxonomy would have followed fast as it is in the nature of mankind[4] to group similar things together and it is probable that its earliest materialisation consisted in the usage of determinatives common to languages of Mesopotamia as well as Ancient Egypt and others[5]. However Sumerian determinatives which have survived in their original form and later used in Akkadian taxonomy might not alway have served their original intention.[6]

1.2 The problem

When masters ordered their scribes to record the ethereal nature of music they would have been facing one of the greatest problems ever. Counting was in its infancy and theorism was still an elusive concept. Here it is contended that it was stringed instruments which held the key to solving this problem and similarly, it is our observation of the iconography, and of rare extant examplars,[7] which will elucidate the earliest phase of music theory.

1.3 Ancient pipes and flutes

Pipes are tubular structures the purpose of which being the generation of sound. There are two main types of pipes: flute-pipes are blown from the open extremity of a tube, the other being closed or open, and reed-pipes, where the tube is open or closed at one extremity and where the sound is generated by a single or double reeds affixed to one of the extremities. Flute-pipes may have distinctive mouth-pieces, either inserted into or affixed around one extremity; or the end of the tube acts as a mouth-piece. Mouth-pieces can be part of the whole structure or may be removable. The fondamental sound on these instruments is generated by the division of the air-flow by means of a *labium*, or the cutting edge part of the sound generator. The pitches are generated from tone-holes the purpose of which being the lengthening or the shortening of the air column. In the present paper, most blown tubular instruments will be called pipes as it is generally impossible to distinguish one from the other in the absence of mouth-pieces/ends, or of reeds.

The rare depictions of wind instruments in the iconography of the Ancient Near and Middle East, and even rarer extant exemplars, do not allow for any conclusions regarding the quantification of pitch sets. Even had the instrumentarium been prolific, observation and conclusions drawn from it would not have been of any value as minimal variations in the bore of the instrument are consequential to the positioning of the holes and their size, and so is the morphology of the mouth-piece or of the hole through which the instrument is blown. Thus the positioning of holes in ancient pipes and calculations made from the ratios of their position cannot be a reliable method for pitch set quantification. In prehistory, most pipes which have been excavated, such as the conjectural Neanderthalian,[8] (fig. 2) to the Chinese models, are all made from bird, bear, and other animals' bones,[9] or even where in instruments such as the silver pipes of Ur[10] which were made of rolled up silver sheets, uniformity of the bore is difficult to achieve. In order to tune a pipe to a particular pitch set, the holes would have to be re-worked and thus a standard jig, or a pattern for drilling the holes to generate a specific scale is therefore inconceivable. On the Jiahu pipe from China, fig. 3) dating back to around 6000 B.C., two of the holes have additional and smaller ones drilled close to them. They would have been used to correct the pitch which might have been slightly off; but they might also have been used to add modal, or other inflections to a pitch.

Pipe players cannot sing and play at the same time. Therefore aerophones could not have been a solitary musician's accompanying instrument, unlike small lutes, lyres, harps, percussion or idiophones. Rare iconographic instances of aerophones never place wind instruments in polyphonic contexts.[11] Pipes of various nature would not have replicated standard pitch sets but might have been intended for the luring of birds, as has been observed from experiments with replications of the Jiahu flute[12]. It is therefore possible that the aforementioned Neanderthalian model would have been a simple 'three or four-holed bone-duct flute' used for luring birds (fig. 4) within bow-shot, rather than it had been an instrument fitted with holes accurately drilled to produce a pre-defined scale for intentional musical performance - It could have been an implement with a completely different purpose.

Figure 2. Photograph of the fragment of a hypothetical Neaderthal pipe, *ca.* 50.000 BC.

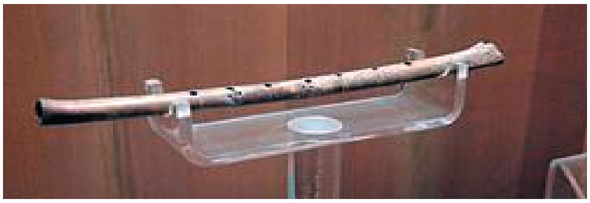


Figure 3. A bone-pipe from Jiahu and detail. *ca.* 6000 BC.

Figure 4. Bone-duct flute for luring birds, from Alkmaar, 13th or 14th century A.D. Length: 7.5 cm, air column: 5.3 cm. (reprinted from Tamboer, A., *Orient-Archäologie, Band 15*).

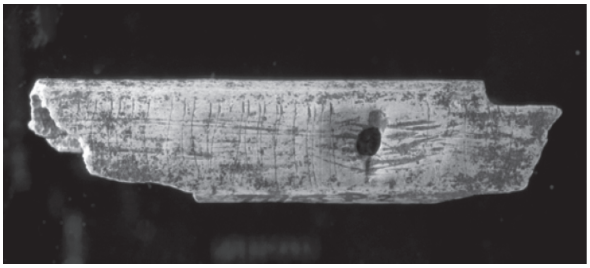


Figure 5. Isturitz Cave, France (Pays Basque), Magdalenian bone fragment showing perforation and markings. Musée National des Antiquités, St Germain-en-Laye. (Photograph by F. d'Errico) *in* Lawson, Music, Intentionality and Tradition, *Orient-Archäologie*, Band 15. 40.000 to 10.000 years old.

The Isturitz fragment is an Upper Palaeolithic find (fig. 5). It comes from a Magdalenian assemblage of twenty-two musical pipe fragments found at a cave in the Pays Basque of France[13]. It is the richest assemblage ever found. (fig. 6)

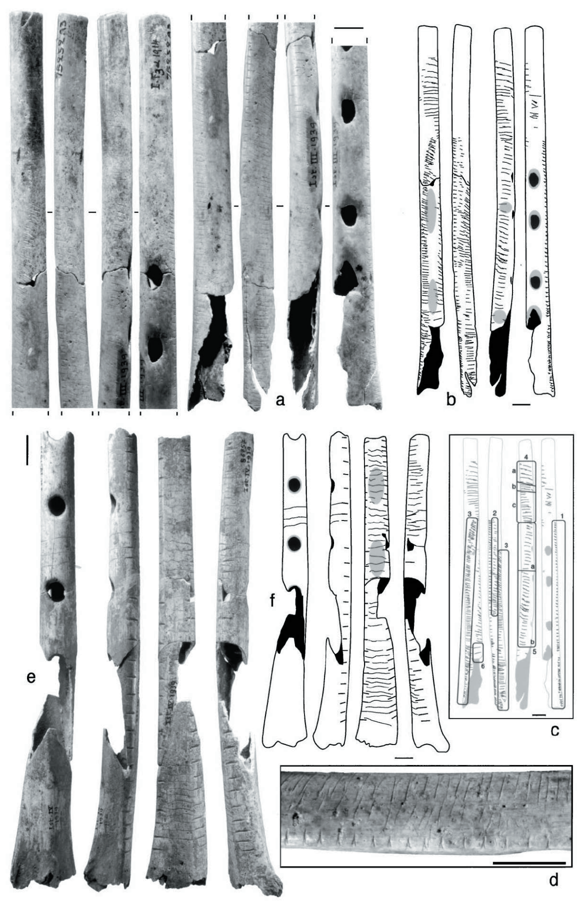


Figure 6. (a, b, e, f) Photo and tracing of the two most complete pipes from the Gravettian levels of Isturitz Cave. Grey areas around the finger holes and at the rear of the pipe indicate concentrations of polish interpreted as use wear; (c) sketch identifying sets of marks made by different tools; (d) close-up view of sets 1–3.

It could be dated from anything between 40.000 and 10.000 years. But are they musical instrument? There are many other possibilities: they could have been devices for mouth-blowing mixtures of air and diluted clay pigments in cave-wall decoration; they could have been needle containers, they could have been ritualistic objects - the list of possibilities is as wide as the imagination.

The markings are most intriguing and would suggest some scaling that might have been used for the positioning of the holes, the part on which they would have been drilled, now missing. The heavy longitudinal marks across the hole resist interpretation.

The number of holes cannot determine the span or the nature of a scale - a three-holed galoubet can play up to two octaves.

1.4 Pan-pipes

These instruments logically predate holed flutes as it is in the nature of mankind to make good usage of what is readily available: It would seems more practical to congregate a number of tubes and adjust their length to specific pitches, rather than drill holes the emplacement of which may not be right and require much empirical adjustment. With pan-pipes, each tube is tuned either by shaving off some of the wood, or bone, from the blowing end or by inserting a substance into the bottom of the pipe thus shortening its speaking length. The substance may be resin, clay, or bitumen, or whatever and where available.

In the absence of textual evidence of their accurate description pipes cannot produce any clues for pitch quantification.

Theoreticians of the Ancient Near and Middle East would have been aware of this difficulty and it is therefore not surprising that there is no evidence of wind instruments in the terminology of theory except for the *embūbum,* Sumerian GI.GÍD[14]. In text CBS 10996[15], *embūbu*[16] appears as an interval of the fifth placed on the third and seventh strings of a hypothetical instrument[17]. The reason for this term being used to name an interval is obscure. It was hypothesised that the *embūbu* was used as 'pitch-pipes', instead of a tuning fork, but this is unsafe unless the *embūbu* had been a double pipe the fundamental open sounds (or others) of which would have sounded a just fifth and from which all other instruments tuned to the same fifth. However, it is likely that in the course of time the word found another meaning altogether and if not unrelated, at least distantly related to the original meaning. It is also possible that the nomenclatures of strings were mnemonic and used words for their phonetic, metric or other values.

1.5 balağ(s), lyres and harps

At the end of the fourth and during the third millennium B.C., large zoomorphic lyres were prominent. (fig. 7) They appeared at royal courts and in religious contexts as revealed in the iconography as well as in the lexical material. According to Krispijn,[18] most of the chordophones listed along with the players, and the songs they accompanied, in the third millennium B.C. are represented with the Sumerian sign balağ or compounds of it. It would therefore be reasonable to assume that the boviform lyres would be balağ(s) unless the sign represented a generic term for chordophones. Therefore, it is safe to assume that the lyre was either the balağ or was a balağ, during the late fourth and the third millennium.

However, 'balağ' is not a Sumerian word. There is Arabic *balagh* a term which implies tension, as in the tension of a string, and we find a 'bolong' in the Guinea Conakry[19] (fig. 8) which strikingly ressembles two particular Elamite instruments, and one from neighbouring Southern Iraq, (fig. 9) as both types are string, percussion and idiophonic at the same time. This particularity might be the explanation for the sign representing string and percussion at different times and at differing places.

Lyrists would have played to accompany their songs and therefore the sounds of their instruments would have been the replication of the sounds of their voice, as we shall see later. It would be inconceivable that they differed.

Harps and lyres fitted with a greater number of strings would have become paradigms and it appears from texts of theory that the number of nine strings was the favoured span, although there is a first millennium instance attesting of a span of seven strings. There are some Assyriologists and musicologists who are of the opinion that the nine strings listed in UET VII 126 (*Nabnitu XXXII*), and 74, specifically represent strings, and not the pitch set

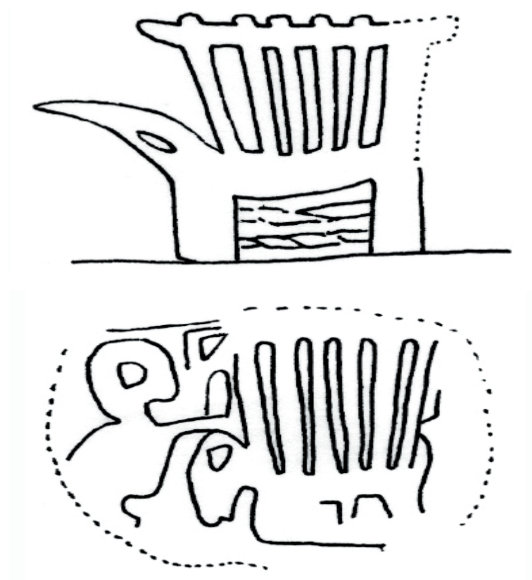


Figure 7. Two zoomorphic lyres from Fara, IVthmillennium B.C.

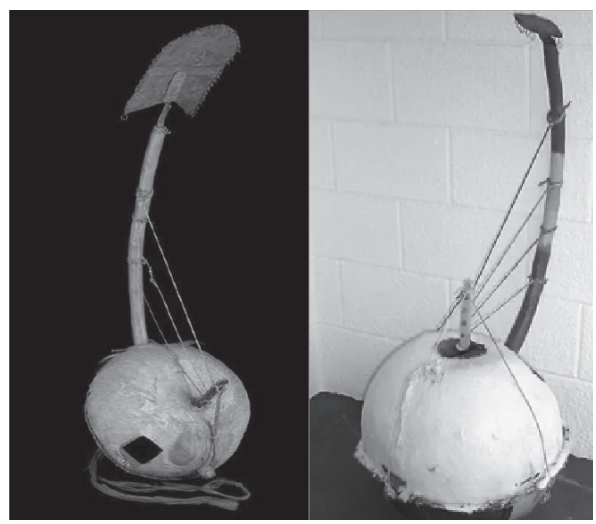


Figure 8. Bolongs from Guinea Conakri.

of a specific instrument and are therefore irrelevant to theory and should remain an organological issue.

However, there is no evidence in any contemporary text that there was segregation between a string and the sound it produced, and why should there be? In a contemporary context, an 'E' string will sound 'E' when tuned to the desired pitch and of course, strings get out of tune, but the primary intention is that they should sound the pitch for which they have been designed and therefore named. The tradition is perpetrated to this day as the names of the strings in most instruments have the name of the pitch they play and in some cases specific names, such as the 'chanterelle'[20] in French,

Figure 9. Elamite and Sumerian (bottom right) balai̯(s)(?)

for the treble string of instruments, such as the violin, or drone, 'bourdon', in French and 'bordone',[21] in Italian, for bass strings and lowest notes in other instruments. Since there is consistency in associating strings in their position to the pitch they produce, it is difficult to understand that its parallel is not yet fully accepted by so many in the field of Mesopotamian archaeomusicology. When texts, distant from each other by about a millennium give identical nomenclatures, coincidence should be excluded, to the profit of persistence. In UET VII 126 = *nabitnu* XXXII, it is an enneachordal arrangement that is given, an ennead, and in UET VII 74, we have instructions for the constructions of scales from a basic ennead. In both texts there is no ambiguity regarding the number of strings, therefore pitches, and therefore an attempt at extracting out of it hepta or octatonic scales is misguided.

1.6 Lutes

The lute appears on seal cylinders (figs. 10 and 11) and date from the Akkadian period, about 2334-2000 B.C. However, there is perhaps an earlier occurence from the Uruk period, around 3200-3000 B.C. (fig. 12) The scene depicts a reed boat, typical of the period, in which a seated woman either appears to be playing a lute or holding a paddle. It is difficult to say which it is. However, the character at the bow is holding a punt pole and therefore there is no reason why the woman at the stern should be holding a paddle.

Lutes in early iconographic art eludes from court and temple scenes mainly for the reason that this instrument was mostly associated with Elamite (and other) rural and street playing, with acrobats, bow-legged dwarfs, monkeys and scenes of acrobatic copulation,[22] and consequently did not have court or temple status. It is very possible that in its earliest forms, the instrument was not fretted, that is without either gut ligatures or fret marks to divide the string in order to locate specific pitches of a specific pitch set, but was more of an idiophone accompanying raucous performance, (fig. 13) rhythmically, and probably not melodically.

The occurrence of fretted lutes, extant and in the iconography, infers that luthiers had knowledge of ratios since it is the approportionating of the string with fret marks or of ligatures on the finger-board which determines the location of its pitches. Lutes have a significant advantage over all other stringed instruments as each ot its strings is tuned to whatever interval between each of them is required, probably a fifth for instruments with two strings, g-d, in order to play g-a-b-c on the bass string, and d-e-f-g-a, on the treble string, to generate an enneachord, and fourths for instrument

Figure 10. British Museum 1888,0512, diorite, 2400 B.C. - 2200 B.C. Akkadian. Author's photograph.

Figure 11. British Museum 1898,1013.139 cylinder seal, serpentine, 2400 B.C. - 2200 B.C. Akkadian. Author's photograph.

Figure 12. British Museum BM 141632, Uruk period. 3500-3200 B.C. Author's photograph.

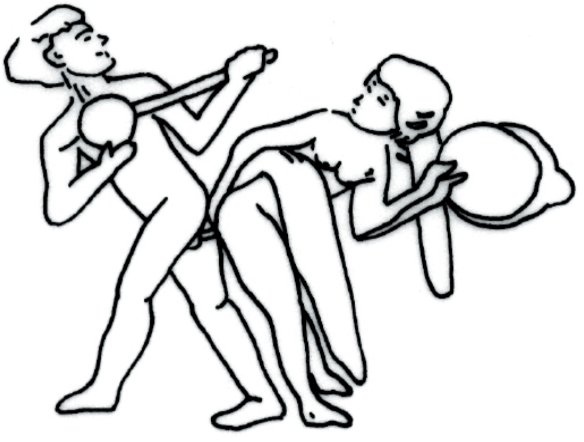


Figure 13. Stamped terracotta from Larsa, 2000-1500 B.C.

with three strings, g-c-f. With harps and lyres, each string must be tuned whatever their number while the lute only requires two or three strings tuned. With the lute, the location of frets in relation to the length of the strings gives ratios of string length. They stand in reciprocal relation to ratios of frequency. Thus it is possible to make accurate quantification for a pitch set from extant instuments, and reasonably good estimations from the iconography.[23]

There is an interesting parallel between tone-hole flutes and lutes, and between pan-pipes and harps. With the latter, each pipe and each string generates its own pitch, and with the former, the pipe and the string divide to produce a series of pitches. It is therefore possible that both tone-hole flutes and lutes developed at the same time, as a consequence of numeracy with the principle of ratios and that therefore pre-literate tone-hole flutes were idiophonic and not devised for a scale based on calculated ratios.

Lutes, therefore, would have been the most suitable instrument for the calculation of musical ratios. However, there is no evidence that they were used for that purpose, possibly because of their connotation with the vulgar rather than the noble.

The only appropriate instrument to illustrate the fundamentals of music could only have been the monumetal lyre, at the end of the fourth, early third millennium, because at that period it was the instrument having the highest status in the instrumentarium, with the largest number of strings. Later, during the Old Babylonian period, *ca.* 1800 B.C., the vertical harp supplanted the lyre, as paradigmatic instrument, since at that period, harps have more strings than lyres. They are also more frequently represented on the iconography. By that time, monumental lyres have vanished. We know this from the iconography and to a limited extent from the archaeology, supported by textual evidence. *Nabnitu* XXXII (U.3011) describes the enneachordal string-plan of a monumental lyre while UET VII, 74, (U. 7/80) describes a nine pitch set construction on an enneachordal harp, and not 're-tuning' to which it is often and erroneously referred. However, *nabnitu* XXXII was written well into the first millennium. Nevertheless it is reasonable to assume from its Sumerian contents and the symmetrical string nomenclature, that it was the copy of a much older treatise, as the string plan of monumental lyres at the end of the fourth, early third millenia, is laid in a fan-like symmetrical disposition reflected in the palindromic nomenclature of the strings in the aforementioned text. It would not have been numbered in this manner had it been taken from the string plan of a harp where the length of the strings is the consequence of a different organological geometry. UET VII, 74, is contemporary with the type of instrument to which it refers, the *sammum*, which, with little doubt but no formal evidence, would have been a harp.

This would have been of critical importance in the developement of theory, as it is the relation between chronology and instrumental typology which has shaped the nature of fundamental theory. Had the relationship been different, the theory too, would have been different, teleologically.

1.7 Conclusion of Part One

This first part has produced the parameters which consitute the infrastructure of theorism. Part two is an epistemological apprehension of music theorism in the Ancient World in relation to the teleology of fundamental theorism, from the analysis of textual, organological and metrological evidence in relation to the neurology of sound perception.

Part Two:
2 The evidence

'It is demonstrable,' said Panglos, teacher of meta-physico-theologo-cosmolonigology, 'that things cannot be otherwise than they are; for as all things have been created for some end, they must necessarily be created for the best end. Observe, for instance, the nose is formed for spectacles; therefore we wear spectacles. The legs are visibly designed for stockings; accordingly we wear stockings. Stones were made to be hewn and to construct castles; therefore my lord has a magnificent castle; for the greatest baron in the province ought to be the best lodged. Swine were intended to be eaten; therefore we eat pork all year round. And they who assert that everything is right, do not express themselves correctly; they should say that everything is best.'

Candide, Voltaire

There are three sources for the evidence: a) The textual and mathematical evidence from cuneiform texts; b) the organological evidence from both extant models and the iconography/ palaeography; c) the neurologic evidence.

a) The cuneiform texts which constitue the essential material for our analysis of music theory are UET VII 126; UET VII 74; CBS 10996 and CBS 1766. There are seconday texts such as N 4782; KAR 158; N3354; BM 65217 + 66616 and MS 5105 in the Schøyen collection, and the Hurrian songs from from Ras al-Shamra to which we shall not refer.

The mathematical evidence comes from four texts from the Temple Library of Nippur, *ca.* 2300 BC.: CBM 11340 + 11402, Obv., and Rev.; CBM 11368 Rev; CBM 11340 + 11402, Rev.; CBM 11902, Obv.; CBM 11097.[24]

b) The organological evidence is from extant instruments suh as the silver lyre of Ur, at the British Museum, London, BM 121199, (U 12354), *ca.* 2500 B.C., from Private Grave (PG) henceforth)/1237, and the Silver Pipes, also from Ur, *ca.* 1450 B.C., from PG/333, at the University of Pennsylvania Museum of Archaeology and Anthropology, Philadelphia. From the iconography/ palaeography: (pictographs: ZATU 47, *ca.* 3200 B.C. Harps with three strings: Dumbrill AANE, Pls. 1: 4; 5; 8; 10; 11; 13; 15; 16; 17; 453; 701. Harps with five strings: 19; 21; 22; 23. Harps with seven strings: 34; 176. Balai̯ ?: Pls. 166; 186; 448? Lyres with five strings: Pls. 18; 280; 293; 294; 297; 338; 527. Lyres with eight strings: Pls. 37; 329. Harps with nine strings: Pls. 286; Lutes: Pls. 9; 218; 221; 231; 233; 244; 412.

c) The neurologic evidence comes from two recent publications[25] by Inbal Shapira Lots and Lewi Stone, for the first paper and by Gavin M. Bidelman and Ananthanarayan Krishnan, for the second.

2.1 Cuneiform Texts

UET VII 126: Tuning concept

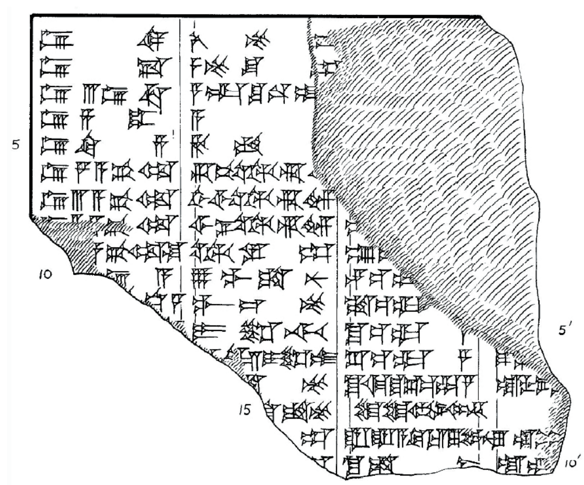


Figure 14. UET VII 126,[26] hand copy by Professor Oliver Gurney, only cols. i and ii are relevant.

UET VII 126 or *Nabitnu* XXXII, (fig. 14) field number U.3011, in the Iraqi museum, is a bilingual text dating from around 800-700 B.C., but would have been the copy of a much older treatise. The left column is Sumerian, the column to its right is Neo- Babylonian.

They translate roughly as follows: front string; next string; third, thin string; fourth, small/ Ea-created-string; fifth string; fourth behind string; third behind string; second behind string; behind string; nine strings.

The set can be simplified as:

(Front) 1 - 2 - 3$^{\text{(thin)}}$ - 4$^{\text{'made' by Ea)}}$ - 5 - 4 - 3 - 2 - 1 (Back)

It is probable that strings three and four of the front had been modified at some point for a specific reason which will be investigated later. Therefore it is reasonable to assume that the original series would have run as follows:

(Front) 1 - 2 - 3 - 4 - 5 - 4 - 3 - 2 - 1 (Back).

The palindromic arrangement would have been written down as a consequence of a scribe's observation with no knowledge in music theory. There is no evidence of scribes specialisating in music theory in collections.

This arrangement would have originally come from the observation of monumental lyres played by two musicians such as depicted on the Inandĩk vase (fig. 15) and in a temple to the Aten in Karnak. (fig. 16) A problem arises, however, in that the Inandĩk model dates from around 1600 B.C., and the Karnak type from about 1300 B.C., while I would date the original instrument to the late fourth millennium. Zoomorphic lyres of the late fourth and third millennia iconography are played by single musicians, only. There are few non-zoomorphic monumental lyres. One example is from a Fara seal impression where the lyre is played by one musician. (fig. 17)

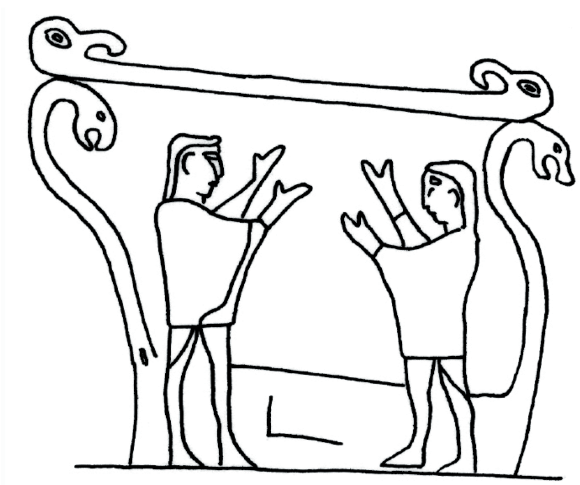


Figure 15. Large asymmetric lyre from the Inandik vase, *ca.* 1600 B.C., AANE, Pl. 516.

Figure 16. Large asymmetric enneachord lyre from Karnak, *ca.* 1300 B.C. (Manniche 54).

The scribe would have looked at the instrument, bridge side. His naming of the strings would have been straighforward. Firstly he would have asked the musician who would have had his own terminology. There would have been a 'front string', and therefore a 'behind string'. It would have been natural to name the front of the instrument the part where the head of the bovid stood; its opposite, the 'behind'. Then it would have been logical to name each of the remaining strings in function of their relationship to the 'front' and to the 'behind', hence, 'first of the front', 'second of the front', 'third of the front', 'fourth of the front'. Naturally, the fifth string is neither of the 'front', nor of the 'behind' and therefore 'string 5' would have defined it adequately. Then, there would have been the, 'fourth of the behind', 'third of the behind', 'second of the behind', and lastly, 'behind string'. Line 10 insists that there are 9 strings, no more, no less.

Strings three and four 'of the front', are further distinguished with qualiyers added to them.

The nomenclature, with qualifiers, as it is inscribed on UET VII 126 was certainly contemporary to its concept, but neither scribe, nor musician would have known from where it stemmed. Similarly, modern musicians do not really know from where the names of the notes come. Practice needs no etymology.

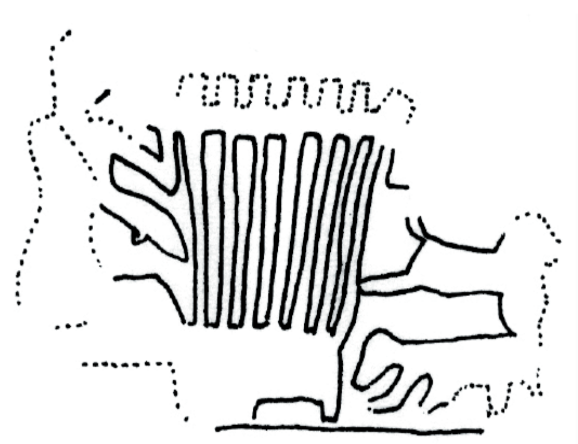


Figure 17. Monumental lyre from a seal impression. Larsa, *ca.* 1300 BC.

The presence of a Sumerian column leads to the assumption that the terms stem from the third millennium and were not a translation of Neo-Babylonian into Sumerian. This is corroborated by an inconsistency in line 4 where the Babylonian is not a translation of the Sumerian. The Sumerian has: sa.4.tur meaning textually 'string four small' while the Babylonian is *a-ba-nu-[ú* meaning 'made by Ea'. This infers that during the Neo-Babylonian period, and probably earlier, possibly from 2500 B.C., that the string had a special function which was so important that it called for the intervention of god Ea who among other functions, was the god of music.

If this assumption is correct, then it would be safe to assume that the Sumerian column had terms which were known in the third, if not the late third fourth millennium B.C. and that therefore the Sumerian qualifiers 'sig' and 'tur', which are almost synonyms, added to the third and fourth front strings inferred an important distinction.

Sumerian sig is translated as *qatnu* in Old Akkadian onward. The English translation is 'third thin', as it is in the Chicago Assyrian Dictionary: (sa.3 sa.sig = *ša-al-šu qa-a[t-nu]* third, thin string (of the harp[27]) Nabnitu XXXII, i, 3). However, in other contexts, sig translates as *ṣeḫru* = small; *ṣeḫeru*, verb (*ṣaḫāru*), to become small; '*šaplu*' = substantive, low; '*šapliš*' = adverb, on the bottom, below, underneath. Therefore, in terms of organology, *šapliš*, or *šaplu* would be more appropriate as the 'smallness', or the ' thinness' of a string, from visual observation would be difficult to appreciate. This qualification could only result from the musician's defining of the sound of the string as being thin, acoustically, that is 'tinny', 'weak', etc. However sig as '*šaplu'*, 'low' and *'šapliš'* = 'bottom' which appears to be more suitable is nevertheless in contradiction with *qatnu*, 'thin' as a thin string has a higher frequency than a 'on the bottom, below, underneath' string, which would be a bass string. So, which had it been bass or treble? The answer to this is probably that the acoustical characteristics of strings three and four would have been difficult to express, in the absence of any theory. Each of these strings would have had different functions, hence the philological distinction of 'sig' and 'tur', that the scribes were unable to distinguish in a musical context. However, an explanation to this will be proposed later in this paper.

In the course of the past four decades, there has been a passionate debate about which part of the instrument is the treble and which is the bass. The question is irrelevant because the disposition is essentially symmetrical. The pitch set is neither ascending nor descending. It ascends or descends from the central string, inconsequently.

The symmetrical arrangement of the strings came from an earlier anhemitonic arrangement: a descending pentatonic scale a-g-f-d-c; and an ascending pentatonic scale g-a-b-d-e, with shared central d. Both combined in this way resulted in enneatonic g-a-b-c-d-e-f-g-a, with a tritone resulting from the conjunction of both pentatonic scales. This is probably how enneatonism was conceptualised.

A span of nine pitches forming a set would have been quite sufficient for playing a wide range of melodies of all types, but it is the introduction of the ≈tritone which was the reason for the introduction of a scale system. This was prompted by the constant necessity for correcting the ≈tritone where ever it was located, but whenever it was corrected, it was simply moved to another set[28].

This correction, or the need for it is illustrated in the string nomenclature. The 'front third thin string' is 'thin' because is does not sound right in relation to its counterpart of the 'behind' as it is tritonic. Now 'front string 4 made, or corrected by the god Ea', infers that the third pitch must be corrected to the pitch of the 4th string in order to correct the tritone to consonnance. This is precisely the method given in UET VII, 74 that we shall discuss later.

Having introduced some terms of theory it is now appropriate to define them, bearing in mind that in its infancy, theory of music would have had no use for them.

There is a fundamental reason why human beings prefer certain intervals to others. Our vocal folds vibrate, generating sound-waves.

These sound-waves are air-borne and travel at a frequency which depends on the atmosphere. As a result, these pitches stand in a just relationship with each other. It is therefore obvious that in turn, the mechanics and the physiology of our ears and of the 'neurons' which carry signals to the cerebral cortex, will respond favourably to the sounds produced by our own vocal folds, hence my quotation of Voltaire's Candide.

Some musicologists[29] are of the opinion that music does not need pitches standing in fixed relationships and perceived as scales made up from a fixed tuning, I will argue, contrarily, that music, without any doubt, needs pitches as there is no music without them. Pitches need to stand in fixed relationships with one another otherwise they would not be perceived pleasantly, and if they do not need to be perceived as scales and do not need to be fixed by natural tuning it is because the cerebral cortex of our brains is already attuned to pitches standing in just relationship to each other.

2.2 The heptatonic myth

Some are of the opinion that heptatonism and the octave are natural phenomena and ignore humankind's natural propensity for just intonation.

Heptatonism is artificial. Its construction which results from the alternation of fifths and fourths, or reciprocally, can only exist within an octavial limitation brought up when mathematics first interferred with music. Thus it is improper to qualify any music as heptatonic unless there is unequivocal evidence for its construction and its inclusion within an octave.

Heptatonism can only exist in relation to the octave because without this limitation, the alternation of fifths and fourths could go on endlessly. (fig. 18) Thus the last pitch of the seventh step of alternation lands one semi-tone higher than the first one giving a 'false octave'. This is where the sequence ends because this problem could not be solved. (fig. 19) In the absence of the octave, heptatonism is elusive.

Figure 18. Sequence of alternating fifths and fourths unlimited by the octavial framework.

Figure 19. Alternation of fifths and fourths forming an heptatonic scale consequence of the octave.

It is therefore illogical to suggest, as Hagel puts it, o*bscurum per obscurius,* that: '*...All the 'tunings' and 'scales' we are dealing with here (Ancient near-East and Ancient Greece) are heptatonic. Even if they are not strictly heptatonic.*'

Even in Ancient Greece, the concept of heptatonism was never clearly defined, at least from the literature. The only evidence of its construction by means of alternation of fifths and fourths, would come from a late translation (12th A.D.) of Euclid's Division of the canon.[30] In Timaeus, Plato constructed the Pythagorean tetrachords from his first tone, D, and going up two 9 /8 tones to E and his chromatic F#, which then stands in 243 /256 ratio to his diatonic G, which was the tone already produced as the harmonic mean of D and D'. But there is no evidence, in this text, of alternation of fifths and fourth. (fig. 20)

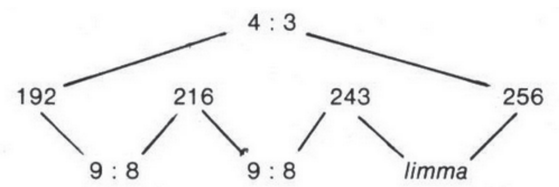


Figure 20. Plato's construction of the tetrachord in Timaeus.

Greece has no texts of theory which have survived from their Ancient History. All we have comes from copies of copies, translations of copies, copies of translations, all in languages ranging from the Syriac to the Arabic, the Farsi, Latin and finally re-written in a 19th century form of Classical Greek.[31] It is therefore presumptuous to claim that the heptatonic construction based on the alternation of fifths and fourths, which anyway is only 'presupposed' in *Timaeus,* to quote West, but which is taken as fact by some, is wishfull thinking. I his XVIIIth theorem of the Κατατομὴ κανόνος, Euclid writes: '... from B, tune a fifth down: Z, Z-D will be a tone. From Z, tune up a fourth to E. The interval BE will therefore be a tone and so will be G-E. Thus the interval they have in comon is D-G; Z-G will therefore be equal to D-E; Z-E is a fourth.' This is hardly proof of a tuning based on alternating fifths and fourths amounting to a heptatonic scale.

Pitch quantification will settle the argumentation. Babylonian enneatonic scale of *pītum*[32] compared to the Pythagorean hypodorian octave species gives the following figues, 'a' for Babylonian and 'b' for Greek. (fig. 21)

a	576	640	720	768	864	960	1037*	1152	1296
b	576	648	729	768	864	972	1024	1152	

Figure 21. 'a', Babylonian figures muliplied by 16 to match 'b' Greek quantification. Note that 1037* = 1036.8

2.3 Just intonation reality

A melody is a congregation of pitches. Their collation amounts to a pitch pool. The order in which the pitches of the pool can be organised, in an ascending or descending order, constitutes a pitch set. Scales are the consequence of the transposition on instruments of the pitches of the voice as the human voice is – as a consequence of its anatomy and physiology – naturally equipped with a propensity for just intonation. (In the course of time, modifications, adaptations, etc., of certain fixed pitches has and will occur, but this belongs to the scope of modality that will discussed later.)

The principle of theorism comes from the conceptualisation of tuning systems for string instruments in replication of the just intonation of the human voice. Since the original method introduced basic metrology, it is evident that theory became a matter for the mathematician and thus the dawn of theory was further distorted by early mathematics.

At the dawn of music theory, the most consonantal intervals would have been just fifths and just thirds, minor and major, in the following order: initial, descending minor third, descending major third, expressed from the ratios 6/6; 6/5; 5/4 with the just fifth 6/4 = 3/2. (Here, I would like to introduce ethnomusicology where it is found that the most primitive forms of music have a propensity for fifths and thirds, as I have discussed in a recent ICONEA seminar on the Psychogenesis of Music Theory.)[33]

The evidence for this prototypical tuning method is given in text CBS 10996, (fig. 22) which although written during the first millennium, would have been the description of a much older concept, probably from the first part of the third millennium. This text is unequivocal. Only fifths (6:4), minor thirds (6/5) and major thirds (5/4) are listed.[34]

2.4 Babylonian tuning

Babylonian tuning would have been approximative because string-instrument making during the early third millennium was not sufficiently developed to allow for optimal sound quality. It must also be reminded that tuning is the musician's task and not the theoretician's. Therefore theory would

Figure 22. CBS 10996.

have had no say in it, only the musician's ear would have mattered. There is no textual evidence for the method consisting in sounding the two opposite degrees of dyads. Therefore we may not assume that the technique had been known. With modern instruments having good sound sustaining, such as the guitar, for instance, the two opposite strings of a fifth are plucked simultaneously, and one or the other is tuned until the frequency of the beats slows down until no longer perceptible. From my own experience with instrument reconstruction, especially with the silver lyre of Ur, the sustaining, while sufficiently long to allow for tuning in this manner, there is no evidence that they used this technique. Babylonians would have played their strings, singing along and tuned them to their voices.

The generation of beats arising from 'un-just' intervals was a phenomenon ignored by theoreticians because these beats, had they heard them, had no purpose in their calculations. The intervals they wrote down were 'sound-less', obviously, and the 'justness' of intervals produced from the experimental monochord was achieved by means of rulers and mobile bridges, or measurements marked alongside the instrument. Music theoreticians were mostly tone deaf, being the reason why they needed mathematics to express what they could not hear.

Therefore there would be no reason why the boviform lyre of the early third millennium would have been tuned with intervals other that just fifths and thirds. It goes without saying that musicians would not have thought of them in terms of ratios. For them tuning came spontaneously.

UET VII 126, (fig. 14) suggests a tuning which consisted in two conjunct fifths within which just thirds were placed. (figs. 23-24)

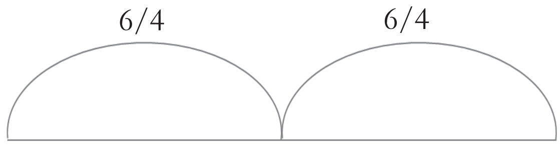


Figure 23.

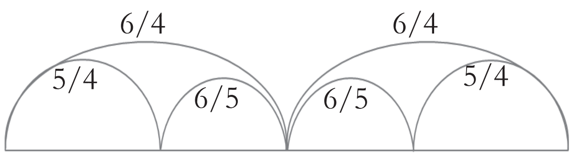


Figure 24.

On the basis of the principle of symmetry which is clearly demonstrated in the nomenclature of UET VII, 126, the arrangement of unaltered pitches would be:

g - b - d - f - a

In ascending or descending order, as has been discussed earlier.

Now comes the argument as to the nature of the pitches in between thirds. How were they tuned?

The postulation generally held by most of my colleagues that what they call dyads or dichords, referring to the intervals in CBS 10996, are empty, is flawed.[35] The evidence is that they must be filled. It is common knowledge that whenever learning intervals, or whenever we wish to explain their nature to students, we sing all of their internal degrees, because it is important to locate semitones for scalar identification. (I use here the term scalar in order not to enter in a debate about tonality and modality which would confuse matters, even more.) When an interval is empty, it has lost its scalar identity. For instance, without knowing within which scale fifths are located, all of them will be just. Within a heptatonic scale system, 6 out of seven fifths will be just.

Regarding thirds, all will be just, four of them minor, and four of them major. However, in the absence of a system of scales, for which we have evidence only in the Old Babylonian period, the nature of fifths and thirds will solely depend on their content. It would be astonishing that in the course of the development of theory, this principle changed.

2.5 Cuneiform Texts

UET VII 74: The concept of scale systems

We have seen that the concept of tuning came from the transposition of voice pitches onto a suitable instrument, probably a boviform lyre, from the late fourth early third millennium and probably well into the first millennium. The concept of a scale system came as soon as the pitches of a set became identifiable as a result of their nomenclature, though tuning. Text UET VII, 74, (fig. 25) dating about 1800 B.C. illustrates this concept, enneatonically.

This text has erroneously been labelled a tuning, or re-tuning text.[36] It is neither a tuning text because the instructions are not for tuning; nor is it a re-tuning text because the instructions are not for re-tuning. The text is about scale construction on an instrument which has already been tuned.

It is now appropriate to discuss the consequences of various tuning methods.

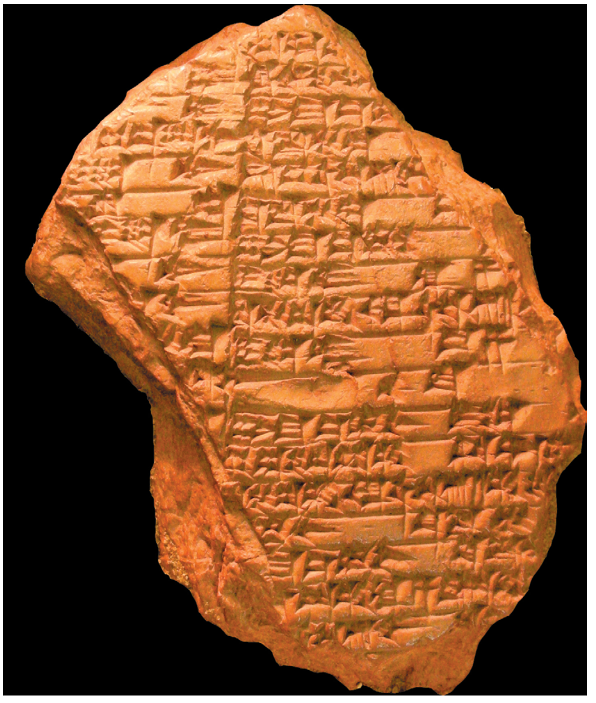


Figure 25. Cast of the original tablet. Author's photograph.

There are many ways in which an instrument can be tuned.

The various methods will determine the nature of the scale which results, and therefore of the scale system generated from it. For instance, should we tune alternating fifths and fourth in one octave, we end up with a Pythagorean heptatonic scale, good for monodic music but totally unsuitable for harmony; should we tune in just fifths and just thirds, we end up with an enneatonic scale excellent for monody but unsuitable for harmony. Should we tune in variable thirds, slightly smaller fifths and slightly larger fourths, as for a modern piano, we end up with equal temperament, good for harmony but poor for monodic music. Each method was and is related to time, space and purpose, but it is logically obvious that the just fifths and just thirds method, the evidence of which we have with UET VII, 126 and CBS 10996, was used in the Ancient Near East, up to the first millennium, naturally excluding heptatonism.

Once the initial tuning completed, the building up of scales can start. There are two methods. Firstly the dynamic and secondly, the thetic methods. The dynamic method consists in staring a scale on each of the pitches of the generative scale, *i.e.*, that is the scale which resulted from the initial tuning. There is no evidence that this was used other than in theoretical works because it would place the top scales at impractical pitches for singers. The thetic method consists in moving the semitone(s) within the generative scale, to another location thus generating another scale. The two methods produce identical systems. However, the dynamic (fig. 26) demands a greater number of strings while the latter operates within an original span.

This system was in usage in the Old Babylonian period, around 1800 B.C., but while the method remainded thetical, it operated differently. While it displaced the semitone(s), this was done with a different concept.

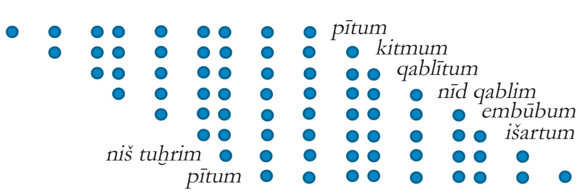


Figure 26.

The thetical method described above (fig. 27) proves that the concept of the octave was unknown during the Old Babylonian period. Had it been, then they would have build up their scales within the octavial heptachordal span:

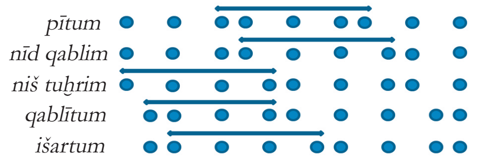


Figure 27.

only seven strings/pitches would have been mentioned because this is all that was needed. Some will argue that the text was devised for the construction of heptatonic scales adapted to an enneachordal instrument. This is not a satisfactory proposition because there were instruments at that time with a varying numbers of strings and therefore, had music been heptatonic then the heptachordal paradigm would have been the standard. There is consistency in the few second and first millennium texts in naming nine strings, except in CBS 1766 that we shall discuss later, and CBS 10996, which is evidently the reduction to the heptachord of a series of intervals spreading over a span of 13 degrees, amounting to three just fifths.[37] It remains that we have consistency in the nomenclature of nine string/pitches over at least a thousand years. Had tuning or system constructions been intended for instruments of varying numbers of string, then it would have been astonishingly coincidental that only nomenclatures of nine strings survived.

Over the past years it has been generally accepted that from UET VII, 74, seven scales could be extrapolated and an eighth landing a semitone higher or lower than from where it started, depending on which chapter of the text. However, The term *pītum* means 'opening' in Akkadian and is also the scale with which the text starts in its present condition. The hypothesis that there were two chapters on the tablet each with eight modes would have resulted in an unreasonably large tablet for the Old Babylonian period, unless of course, the text had been spread on a series of normal sized tablets. However, for a text of that importance, it would be possible that it had been written all on one tablet and that therefore there were only 4 scales in each chapter with a central scale, *išartum*, a total of 5 scales. This argument is critically reinforced, confusing heptatonicists even further, because should there be only 5 enneatonic scales, then each could host 3 heptatonic or 2 octatonic making the current reconstruction of the text pointless.

2.6 The enneatonic reformation

This reformation, initially coined by my colleague and friend Leon Crickmore, is the consequence of mathematics. The science led the way to Babylonian heptatonism in the first millennium. I contend that this took place as soon as mathematicians took over from empirical theoreticians, and explored ratios of string length. Empirical theoreticians, who were nothing more than observant scribes, only noted string lengths, but did not appreciate them as ratios. I am of the opinion that god numbers appearing during the Babylonian period would have been used as standards for many measurements and probably also for musical metrology. Anu was the god of 60. This would have been the length of a lute string of 60 *ubanātu*, or fingers, about 96 centimetres; Enlil at 50 would locate the first fret; Ea, 50, the third fret and Sin, 30, the fourth fret. Ea was also known as the god of 2/3 which reinforces the hypothesis. This would set the tonal framework: Fundamental = 6/6; a descending minor third, at 6:5, a descending major third at 5:4, therefore a descending fifth of 6:4 (=3/2) and the octave at 6/3 (=2/1). Intermediate pitches would be set by ear, probably in a 'pseudo modal' context that we shall explore later.

Then, around 2300 B.C., Nippur mathematicians produced various mathematical tables.[38] Four of them, among thousands, excavated at the Temple Library of Nippur were hand-copied transliterated and translated by Hilprecht and published in 1906. Their collation produced a list of numbers, notably from 36 to 80, as follows: 36; 40; 45; 48; 54; 60; 64; 72; 80. The relationship these numbers have between each other expresses just intervals of an enneatonic pitch set. There are two additional numbers, 81, and 50. 81/80[39] is the syntonic comma and 50/48 is the small semi-tone. This probably the reason for their presence in the tables, and also because their are regular numbers expressing just intervals.

Comparing these numbers to the previous quantification given previously in this paper, shows that at that time, there had been some reformation of pitch quantification: (fig. 28)

a	36	40	45	48	54	60	64.8	72	81
b	36	40	45	48	54	60	64	72	80

Figure 28.

Row 'a' is the old system, probably Sumerian (which would not have been used until around 2300 B.C.) and row 'b' which is the reformed system, dating around 2300 B.C. where we have two types of tones: 9/8, the major tone and 10/9, which is the minor tone of just intonation; and a just semi-tone of 16/15.

A tuning for this system would have included just fourths, and as a consequence the introduction of a Pythagorean minor third: 64/54 = 294.135 cents. An acute fourth was also introduced: 54/40 = 520 cents. However, this tuning was not an ascending, or a descending alternation of fifths and fourths, but a projection of fifths and fourths from the central note, 'd' as shows below (fig. 29):

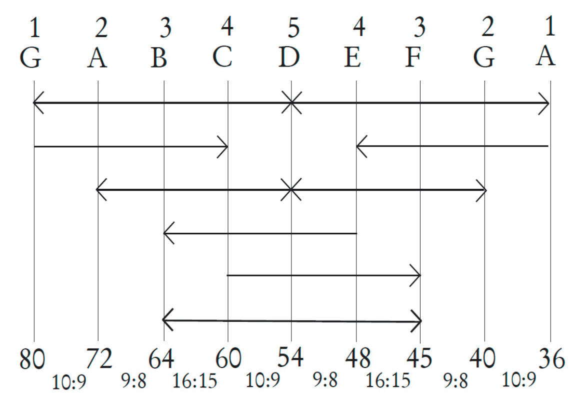


Figure 29.

Mathematicians had taken control over from theoretical empiricism. It would not take long before they discovered the octave. There is yet no term for it in the philology, or would there be one, it would have escaped our perspicacity. However, it is implied in the ratio of god Anu to Sin: 6/3 = 2/1, but this does not consitute evidence that they would have used it in relation to heptatonical construction or otherwise.

The textual evidence expresses the confusion that was brought along when mathematics clashed with the empirical theory of scribes or musicians. The symmetrical system in which they had found perfection was proven less than perfect with mathematics, especially with 64.8 which did not fit in the greatest scheme of justness but was in a way undeniable proof of an evil and inexplicable dissonance as the ratio of 64.8/45 is 631 cents, not quite a tritone, but an acute diminished fifth, but certainly a dissonant interval. This shows how hemitonism proved a difficult concept compared to the simplicity of anhemitonism where dissonance is unknown.

2.4 The advent of heptatonism

Heptatonism is a mathematical concept, irrelevant to music practice and which theoreticians spread around liberally whenever they need to categorize music which is not pentatonic. It is a bit like archaeologists having just dug out an unidentifiable object which will eventually end up in a museum as 'cultic'.

The definition given by Wikipedia makes of it a form of universal panacea where, I quote, are included the major scale; the melodic minor; ascending and descending harmonic, minor and major; Byzantine; Hungarian; Gypsy; Egyptian; Heptonia Prima and Secunda; Heptonia Tertia; Verdi's Scala Enigmatica; Melakarta; Thaat; Chinese Gongche notation, etc.

There is a need for a definition as a number of seven pitches that can be included within an octave does not necessarily mean that the scale is heptatonic since the set might well spread beyond, or below the octavial incarceration.

While theoreticians of modern music might wish to establish their own definition of the term, I should like to preconize a definition suitable to its construction in Antiquity inasmuch as it differs from other scale constructions.

Once more, as it has been the case during the argumentation in this paper, textual evidence is the basis for definition. With heptatonism, it is text CBS 1766 (fig. 30) which constitures the evidence. It was bought among the Khabazu acquisitions, by the University Museum of the University of Pennsylvania, and may have originated from Sippar. It is difficult to date the text because its archaeological context is unknown. However, on the basis of its contents and of the illustration it has, I would date it around the turn of the first millennium, that is 1000 to 700 B.C. The text has a header to a table that Jerome Coburn[40] has attempeted at reading with interesting conclusions that shall not be discussed here.

Figure 30.

Early in June 2007, Caroline Waerzeggers and Ronny Siebes[41] from the Vrije Universiteit in Amsterdam proposed an alternative interpretation to a paper published by Wayne Horowitz, of the Hebrew University, in the Journal of the Ancient Near Eastern Society[42]. It was originally published by Hilprecht over one hundred years ago in his Explorations in Bible Lands During the 19th Century.[43] This volume included a photograph of the inscribed side with the label: 'Astronomical Tablet from the Temple Library'.

The tablet is divided in two sections. (fig. 31) The first section, at the top left consists of a heptagram[44] with annotations, inscribed within two concentric circles. The second section, below the heptagram, is a table with 11 columns of which the first is empty, with traces. Columns two and three are inscribed with two lists of seven numbers each; column four is empty without any traces; and columns five, six and seven are inscribed with only one line of numbers. A header spreads along the whole length of the columns; column 11 has traces of terms.

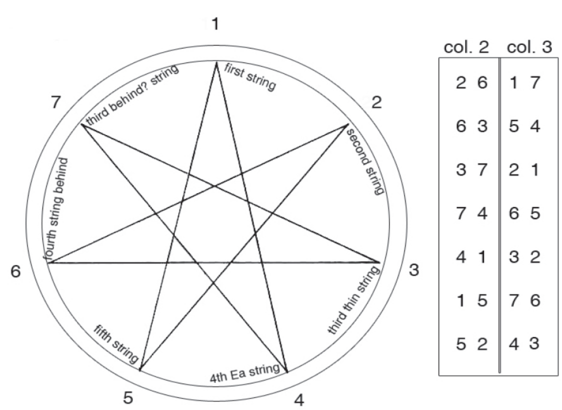


Figure 31.

The readings of the first two columns to the left of the table and the nomenclature of the heptagram are undisputed and yield, it is contended, the essential of what the text has to offer. However, we shall only consider the heptagram and the figures in column two since they are essential to the argument.

2.5 The heptagram and heptatonism

Any musicologist presented with a heptagram would conclude that the figure is a diagrammatic explanation for the formation of the heptatonic diatonic musical scale. They would expect to find numbers, notes, pitches or degrees on each of the points of the star, starting at the top, and then explain that the intersecting lines linking the numbers would describe the alternation of intervals of fifths and fourths which are the basis for the formation of the heptatonic paradigm. Should they wish to illustrate further the principle, they would draw a table with a series of numbers which would flow in the following sequence: 1-5-2-6-3-7-4-1, as a complementary explanation of how the heptagonal construction works.

Should they substitute notes for numbers, as they are displayed on the circumference, clockwise, then the notes could be any ascending or descending series starting on any note of the heptatonic scale: c-d-e-f-g-a, or b.

It is therefore unsurprising that the names and numbers which appear on the heptagon in CBS1766 are precisely what our music theoretician would have said, without hesitation, about a similar pattern. Indeed, the number at the top of the heptagon is 1 and its nomenclature is *qú-ud-mu*, meaning the first string, unsurprisingly. The orthography diverges from UET VII 126. There we have Sumerian sa.di with Akkadian equation *qud-mu-u[m*. The second term, clockwise, is headed with number 2 followed by *sa-mu-šum*, close enough to *sa-mu-šu-um* in the same UET; the term which follows is not readable but it must have been *šal-al-šu qa-at-nu* since this is what follows in our text of reference; then we have *a-banu* rightly followed by *ḫa-an-šu* and *re-bi? úḫ-ri*. The sequence ends with number 7, *šal-šu* [XX]. The last signs resist reading but we would expect something expressing that it was the 'xth behind-string', *i.e.*, the 'xth last string' as we have it in UET VII 126. Now, that the numbers in the table are substituted for the names of the strings on the heptagram is of high significance as this constitutes the first instance in the history of music of a dichotomy between the string itself and the sound it produces. The string is called 'x' but its value is '1', therefore it could also be '2', '3' or whatever number of degrees they had in their scale, in this case, up to degree '7'.

This proves that they would, by now, have distinguished the dynamic from the thetic disposition.

The second column, which includes two descending series of numbers, can be interpreted as follows: Firstly, we may read the first series, from top to bottom as 2-6-3-7-4-1-5, or twin it, in horizontal reading, with the second series: 6-3-7-4-1-5-2 and read it this way: [2-6/6-3][3-7/7-4][7-4/4-1][1-5/5-2]. In both cases, we end up with the same construction.

This text proves beyond possible doubt that a) the concept of a genuine heptatonic construction resulting from alternation of fifths and fourths was known in the first millennium B.C.; b) that the enneatonic pitch set was now reduced to the heptatonic; c) that the dynamic disposition was by now preferred to the thetic disposition; d) that numbers were now used to indicate the relative position of scales in the system. Hence they would have had the scale of the first degree, of the second, of the third, etc.

This proof of heptatonism will further support the nature of the previous enneatonic construction which was itself the consequence of an anhemitonic, probably pentatonic ancestor. While all previous texts discussed in the present paper are enneatonic with traces of anhemitonism, CBS 1766 is archetypical of heptatonism where no more traces of either penta- or enneatonism survive. Thus the construction that Hellenists had wishfully thought that it belonged to Greek theory, emerged from the sands of Mesopotamia rather than from the shores of Greece. It is therefore highly probable that the Greeks 'acquired' the principle of heptatonism during the Orientalizing Period[45] in the later part of the 8th century B.C. When the Pythagorean School developed, all had been forgotten of its Eastern origins.

Part three
3 Neurologic evidence

Two recent studies: a) *Perception of musical consonance and dissonance: an outcome of neural synchronisation*, by Inbal Shapira Lots and Lewi Stone, Biomathematics Unit, Faculty of Life Sciences, Tel Aviv University, Israel, 2008, and b) *Neural Correlates of Consonnance, and the Hierarchy of Musical Pitch in the Human Brainstem*, by Gavin M. Bidelman and Ananthanarayan Krishnan, of the Department of Speech Language, Purdue University, USA, 2009, have discussed the preference for consonantal intervals.

Both teams have been mislead by the Pythagorean dictate. Therefore the nature of the intervals they analysed are not really representative of the hierarchy of just or natural ratios defined in the Ancient Near East. However, I have chosen to include their conclusions in the present paper on the basis that they support my hypothesis of human kind's production of sound and therefore preference for natural intervals, from which early theories developed, as I have explained in this paper. This shows that the postulation held by most musicologists that all known systems in the Ancient Near East are heptatonic is flawed.

A number of theories have been proposed as to why consonance is related to simple frequency ratios. Lots and Stone have explored the theory of synchronisation properties of ensembles of coupled neural oscillators to demonstrate why simple frequency ratios may have achieved a special status and why they are important for music perception.

The analysis shows that mode-locked states ordering give precisely the standard ordering of consonance as given in Western music theory. The results show the importance of neural synchrony in musical perception. Having presented a theory of consonance and dissonance, it is important to emphasize that the effects described are intended to deal solely with just intervals outside of any musical context in order to exclude emotional components such as harmonic progressions. Thus, jazz, or other dissonances falls outside the scope of this theory. The model serves to explain why human preference for simple frequency ratios in pure tones may be a natural consequence of neural synchronization.

Bidelman and Krishnan argue that consonnantal and dissonantal pitch relationships are the fondamentals of Western music. They hypothesize that phase-locked neural activity within the brainstem may preserve information relevant to these important perceptual attributes of music. To this end, they measured brainstem frequency-following responses from non musicians in response to the dichotic presentation of nine musical intervals varying in their degree of consonance and dissonance. Neural pitch salience was computed for each response using temporally based autocorrelation and harmonic pitch sieve analyses. Brainstem responses to consonant intervals were more robust and yielded stronger pitch salience than those to dissonant intervals. In addition, the ordering of neural pitch salience across musical intervals followed the hierarchical arrangement of pitch stipulated by Western music theory. Finally, pitch salience derived from neural data showed high correspondence with behavioral consonance judgments.

These results suggest that brainstem neural mechanisms mediating pitch processing show preferential encoding of consonantal musical relationships and, furthermore, preserve the hierarchical pitch relationships found in music, even for individuals without formal musical training. It was inferred that the basic pitch relationships governing music may be rooted in low-level sensory processing and that an encoding scheme which favours consonantal pitch relationships may be one reason why these intervals are preferred.

Interval	Musical pitches	No. of semitones	Ratio of fundamentals	Frequency components (Hz)
Unison (Un)	**A3, A3**	**0**	**1:1**	Note 1: ***220, 440, 660, 880, 1100, 1320*** Note 2: ***220, 440, 660, 880, 1100, 1320***
Minor 2nd (m2)	A3, B♭3	1	16:15	220, 440, 660, 880, 1100, 1320 235, 470, 705, 940, 1175, 1410
Major 3rd (M3)	**A3, C#4**	**4**	**5:4**	**220, 440, 660, 880, *1100*, 1320** **275, 550, 825, *1100*, 1375, 1650**
Perfect 4th (P4)	**A3, D4**	**5**	**4:3**	**220, 440, 660, 880, 1100, 1320** **293, 586, 879, 1172, 1465, 1758**
Tritone (TT)	A3, D#4	6	45:32	220, 440, 660, 880, 1100, 1320 309, 618, 927, 1236, 1545, 1854
Perfect 5th (P5)	**A3, E4**	**7**	**3:2**	**220, 440, *660*, 880, 1100, *1320*** **330, *660*, 990, *1320*, 1650, 1980**
Major 6th (M6)	**A3, F#4**	**9**	**5:3**	**220, 440, 660, 880, 1100, 1320** **367, 734, 1101, 1468, 1835, 2202**
Major 7th (M7)	A3, G#4	11	15:8	220, 440, 660, 880, 1100, 1320 413, 826, 1239, 1652, 2065, 2478
Octave (Oct)	**A3, A4**	**12**	**2:1**	**220, *440*, 660, *880*, 1100, *1320*** ***440, 880, 1320*, 1760, 2200, 2640**

Table 1. Musical interval stimuli used to evoke brainstem responses. Values in italics represent frequency components shared between both notes in a given dyad. Intervals in bold were taken are consonnantal by the authors; intervals in lightface were taken as dissonant by the authors. Harmonics of individual notes were calculated from the ratio of their fundamental frequencies in just intonation. (Gavin M. Bidelman and Ananthanarayan Krishnan)

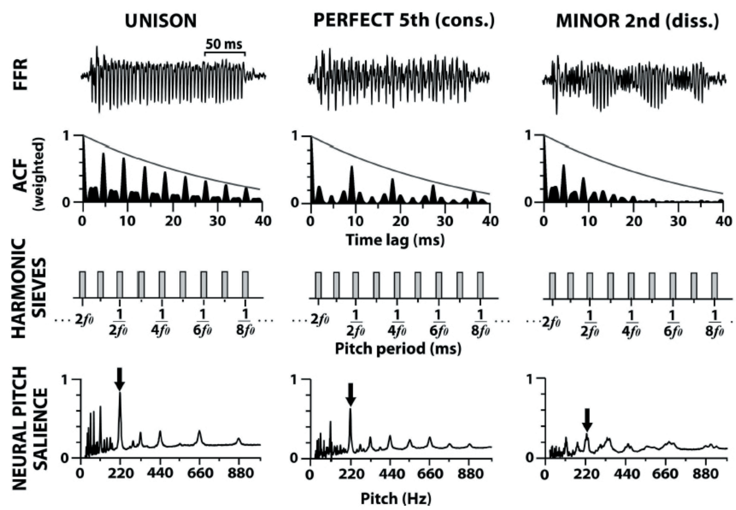


Table 2. Procedure for computing neural pitch salience from FFR (frequency-following response) responses to musical intervals [unison, perfect fifth (consonant), and minor second (dissonant) shown here]. Dichotic presentation of a musical dyad elicits the scalp-recorded FFR response (top row). From each FFR waveform, the autocorrelation function (ACF) is computed and time weighted with a decaying exponential (solid gray line) to calculate the behaviourally relevant periodicities present in the response (second row). Each ACF is then passed through a series of harmonic interval pitch sieves consisting of 'windows' centered at f0 and its integer harmonics (third row). Each sieve template represents a single pitch and the magnitude of the output of each individual sieve represents a measure of neural pitch salience at that pitch. Analyzing the outputs across all possible pitches (25–1000 Hz) results in a running pitch salience for the stimulus (fourth row). As the arrows indicate, the magnitude of pitch salience for a consonant musical interval is more robust than that of a dissonant musical interval (*e.g.*, compare perfect fifth to minor second). Yet, neither interval produces stronger neural pitch salience than the unison. (Gavin M. Bidelman and Ananthanarayan Krishnan)

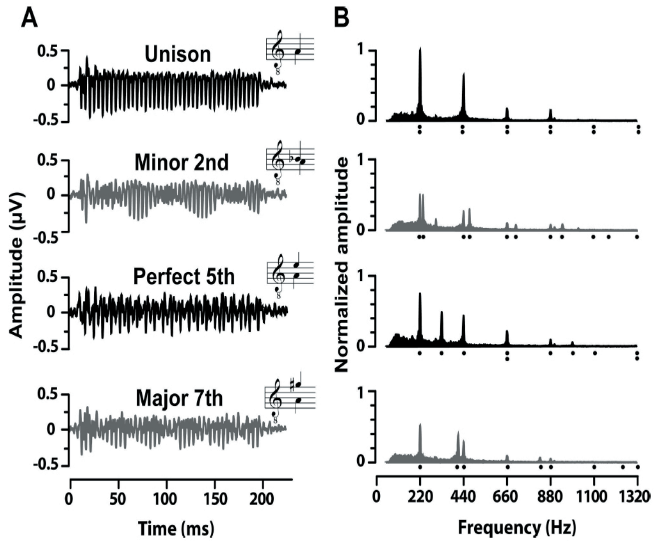


Table 3. Grand-average FFR waveforms (A) and their corresponding frequency spectra (B) elicited from the dichotic presentation of four representative musical intervals. Consonant intervals are shown in black, dissonant intervals in gray. A, Time waveforms reveal clearer periodicity and more robust amplitudes for consonant intervals than dissonant intervals. In addition, dissonant dyads (*e.g.*, minor second and major seventh) show significant interaction of frequency components as evident from the modulated nature of their waveforms. Insets show the musical notation for the input stimulus. B, Frequency spectra reveal that FFRs faithfully preserve the harmonic constituents of both musical notes even though they were presented separately between the two ears (compare response spectrum, filled area, to stimulus spectrum, harmonic locations denoted by dots). Consonant intervals have higher spectral magnitudes across harmonics than dissonant intervals. All amplitudes are normalized relative to the unison. (Gavin M. Bidelman and Ananthanarayan Krishnan)

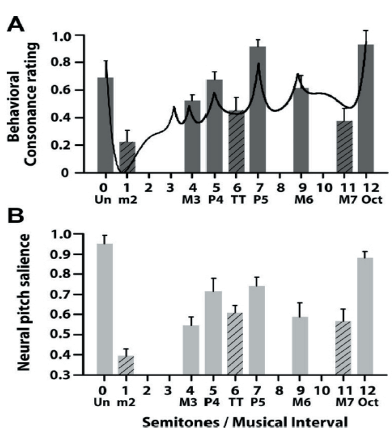


Table 4. Perceptual consonant ratings of musical intervals and estimates of neural pitch salience derived from their respective FFRs. Solid bars, Consonant intervals; hatched bars, dissonant intervals. A, Mean behavioral consonance ratings for dichotic presentation of nine musical intervals. Dyads considered consonant according to music theory (solid bars) are preferred over those considered dissonant [minor second (m2), tritone (TT), major seventh (M7)]. For comparison, the solid line shows predictions from a mathematical model of consonance and dissonance (Sethares, 1993) in which local maxima denote higher degrees of consonance than minima, which denote dissonance. B, Mean neural pitch salience derived from FFR responses to dichotic musical intervals. Consonant intervals produce greater pitch salience than dissonant intervals. Even among intervals common to a single class (e.g., all consonant intervals) FFRs show differential encoding resulting in the hierarchical arrangement of pitch described by Western music theory. Error bars indicate one SEM. (Gavin M. Bidelman and Ananthanarayan Krishnan)

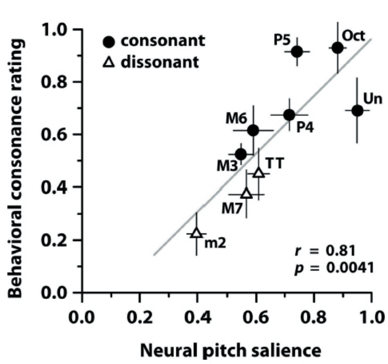


Table 5. Neural pitch salience derived from FFRs versus behavioral consonance ratings. Consonant intervals elicit a larger neural pitch salience than dissonant intervals and are judged more pleasant by the listener. Note the systematic clustering of consonant and dissonant intervals and the maximal separation of the unison (most consonant interval) from the minor second (most dissonant interval). Error bars indicate one SEM in either the behavioral or neural dimension, respectively. (Gavin M. Bidelman and Ananthanarayan Krishnan)

General conclusion

This paper will have suffiently shown that heptatonism did not appear spontaneously on the musical scene of the Ancient Near East. The textual evidence is unimbiguous as there are no traces of any heptatonic construction before the first millennium B.C.

Neural correlates of consonnace and dissonance in the human braistem will have proven to musicologists that heptatonism being the result of mathematical interference in the justness of natural tuning, is artificial and that therefore the universal reference to it in comparative musicology is misguided.

On the other hand, textual evidence shows empirical methods which led from anhemitonism to enneatonic diatonism. During the second millennium there is evidence of a struggle between old and new systems as the old enneatonism built uniquely on just fifths and thirds had flaws. This was partially solved by an intermediate system where enneatonism made its way to proto heptatonism. Then all was finally resolved in the first millennium where we have for the first time evidence of a heptatonic construction made from the alternation of fifths and fourths, unequivovally and strictly limited to the heptad.

Neural correlates of consonnace in the human braistem, adding to the evidence produced all along in this paper will once and for all, it is hoped, enlighten ceratin musicologists that heptatonism being the result of mathematical interference in the justness of natural tuning, is artificial and was not, therefore a system which appeared spontaneously in the history of musical theorism.

Before heptatonism could be satisfactorily realised, there were many empirical procedures some of which having survived in Ancient Near Eastern texts and probably elsewhere.

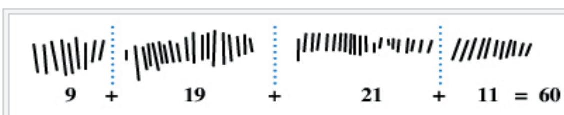
Notes

1 Here, I use the word theorism as describing a state of mind which in antiquity had become educated and was propicious to the construction of theory as a consequence of numeracy and literacy; not to be confused with theoreticism which is the preference for theory over practice or, more broadly, abstract knowledge over concrete action, or a philosophical position which would lead to such a preference.

2 The three columns of asymmetrically grouped notches suggest that the implement might have been used for the construction of a numeral system. The central column begins with three notches, and then doubles to 6 notches. The process is repeated for the number 4, which doubles to 8 notches, and then reversed for the number 10, which is halved to 5 notches. These numbers may not be purely random and instead suggest some understanding of the principle of multiplication and division by two. The bone may therefore have been used as a counting tool for simple mathematical procedures. Furthermore, the numbers on both the left and right column are all odd numbers (9, 11, 13, 17, 19 and 21). The numbers in the left column are all of the prime numbers between 10 and 20 (which form a prime quadruplet), while those in the right column consist of 10 + 1, 10 − 1, 20 + 1 and 20 − 1. The numbers on each side column add up to 60, with the numbers in the central column adding up to 48. See hand copy below.

Left column

Center column



Right column

See: *A very brief history of pure mathematics*: The Ishango Bone University of Western Australia School of Mathematics; Rudman, Peter Strom (20007); *How Mathematics Happened: The First 50,000 Years*. Prometheus Books. p. 63; de Heinzelin, Jean: 'Ishango', *Scientific American*, 206:6 (June 1962) 105-116; Williams, Scott W.: 'Mathematicians of the African Diaspora' *The Mathematics Department of The State University of New York at Buffalo*; D. Huylebrouck, 'The Bone that Began the Space Odyssey', *The Mathematical Intelligencer* vol 18 no. 4; Gerdes, Paulus (1991): On The History of Mathematics in Africa South of the Sahara; *African Mathematical Union, Commission on the History of Mathematics in Africa*; Marshack, Alexander (1991): *The Roots of Civilization*, Colonial Hill, Mount Kisco, NY; etc.

3 The relationship between language and gender has long been of interest within sociolinguistics and related disciplines. Early 20th century studies in linguistic anthropology looked at differences between women's and men's speech across a range of languages, in many cases identifying distinct female and male language forms. Gender has also been a social variable in quantitative studies of language variation carried out since the 1960s, a frequent finding being that, amongst speakers from similar social class backgrounds, women tend to use more standard or 'prestige' language features and men more vernacular language features. Aspects of interpretation and of the methodology adopted in variationist studies have however been criticised by some language and gender researchers (see discussion in Cameron, 1992; Coates, 1986/2004; Graddol and Swann, 1989).

4 And of certain insects. About 35 species of ants are helotistic, meaning that they select and enslave selected alien ant species to sustain their colony. However, this is the result of a sophisticated behaviour pattern which cannot be equated to taxonomy as the consequence of numeracy/literacy. (See Wilson, O.E., Slavery in Ants http://antbase.org/ants/publications/13347/13347.pdf); Anne Kilmer offers an interesting proposition with regard the possibility of pre-literate taxonomy in 'Memorizing the Names of Things, From Oral to Written: Mesopotamian Musical Instruments' in *Orient-Archäologie* Band 15. Helen Hickmann/Ricardo Eichmann (Hrsg.) *Studien zur Musikarchaologie IV*, 2004:139-41. There, it is regrettable that the balaḫ is translated as harp regardless of the fact that it is currently impossible to determine what the balaḫ would have been at different times of its evolution, both philologic and organologic.

5 A determinative, also known as a taxogram or semagram, is an ideogram used to mark semantic categories of words in logographic scripts. They have no direct counterpart in spoken language, though they may derive historically from glyphs for real words, and functionally they resemble classifiers in East Asian and sign languages. In cuneiform texts of Sumerian, Akkadian and Hittite languages, many nouns are preceded or followed by a Sumerian word acting as a determinative; this specifies that the associated word belongs to a particular semantic group. These determinatives were not pronounced. Some 90% of Chinese characters are determinative-phonetic compounds; the phonetic element and the determinative (called a radical) are combined to form a single glyph. (See Edzard, Dietz Otto, 2003. Sumerian Grammar. Handbook of Oriental Studies. 71. Atlanta: *Society of Biblical Literature*. ISBN 1-58983-252-3).

6 Both the meaning and pronunciation of the characters have shifted over the millennia, to the point that the determinatives and phonetic elements are not always reliable guides. Whether a given sign is a mere determinative (not pronounced) or a Sumerogram (a logographic spelling of a word intended to be pronounced) cannot always be determined since their use is not always consistent. For example the determinative 'GI' = reed which initially was used to describe objects made of reed, such as reed pipes, might have been used, under the stylus of a specialised scribe to describe any type of pipes, some made of reed or of other materials such as silver as with time the classification of the instrument would have become more important that the medium of which it was made. Moreover, this practice would have been emphasised by the jargon of specialised scribes who would have, in relation to their speciality, modified the meaning of specific determinatives to suit the description of items belonging to their trade. Thus determinatives are not necessarily reliable taxonomic identifiers if interpreted generally rather than studied in relation to specific scribal jargon. This survives today as when, for instance we refer to the family of brass or woodwind instruments, where some of them may be made of plastic and when referring to the family of strings, violins produced from a synthesiser have no strings. In a Chinese dialect of the Jiahu region (The Jiahu gǔdí (贾湖骨笛) is the oldest known musical instrument from China, dating back to around 6000 B.C. (Gǔdí literally means 'bone flute') where 8000 years old bone pipes were excavated. The word for bone = 'ku', a determinative, and the substantive for flute 'di', stuck together to end up as the one word 'gǔdí'. Woon gives an extensive list of the various translations of 義符 yìfú: semantic element, radical, determinative, signific, signifying part, significant, significant part, semantic part, meaning element, meaning part, sense-indicator, radical-determinative, lexical morpheme symbol, ideographic element, and logographic part. Among these, 'radical' and 'ideographic' have both been strenuously objected to as misleading. (See Woon, Wee Lee, 雲惟利, 1987. Chinese Writing: Its Origin and Evolution. 漢字的起源和演變). Originally published by the University of East Asia, Macau. Available through Joint Publishing, jpchk@jointpublishing.com). See also Boltz, William G. (1994; revised 2003). The Origin and Early Development of the Chinese Writing System. *American Oriental Series*, vol. 78. American Oriental Society, New Haven, Connecticut, USA. ISBN 0-940490-18-8. For more on the gǔdí, see Zhang, JuZhong, Garman Harboolt, Changsui Wang, and ZhaoChen Kong. 'Oldest playable musical instrument found at Jiahu early Neolithic site in China.' *Nature*. 23 September 1999. 4 February 2007. <http://www.nature.com/nature/journal/v401/n6751/pdf/401366a0.pdf>.

7 Lyres: The so-called Gold Lyre, Iraq Museum, Baghdad, (B 8694; U 12353). This lyre has been seriously damaged during the looting of the museum; Silver Lyre, British Museum, London, (BM 121199; U 12354); Boat-shaped Lyre, University of Pennsylvania Museum of Archaeology and Anthropology, Philadelphia, (UPM 30-12-253; U12355); Plaster Lyre, Iraq Museum, Baghdad, (B 8695; U 12351); Lapis-bearded Lyre, University of Pennsylvania Museum of Archaeology and Anthropology, Philadelphia, CBS 17694, CBS 17684; U 10556); copper bull's head with mosaic band and shell plaques from a lyre, University of Pennsylvania Museum of Archaeology and Anthropology, Philadelphia (UPM 30-12-484,-696; U 12435) silver bull's head and shell plaques from a lyre, University of Pennsylvania Museum of Archaeology and Anthropology, Philadelphia, (CBS 17065; U 10916); lyre from Pu Abi's grave, British Museum, London, (BM 121198; U 10412); copper bull's head and shell plaques from a lyre, British Museum, London, (BM 121533; U 10577). Harps: harp with silver sleeve and mosaic border, British Museum, London, (123675; U 11781); harp from Pu Abi's grave, British Museum, London (BM 121198; U 10412).

8 http://www.greenwych.ca/fl-compl.htm

9 Bones were not the only materials from which pipes and flutes were made. Bone survives much longer than wood but a less acidic soil would have certainly produced models made of reed or of hollow branches of the elder, the *sambuca*, once the pith removed. The Latin *sambuca* has a disputed etymology. Molinari writes that it comes from the Arabic and is the name of an anise-flavoured drink that arrived to the port of Civitavecchia by ships coming from the East. In the OED, the word stems from Latin *sambucus*, the elder tree. Latin *sambūca* is the equation of Greek *sambŷkē*. There is an earlier reference as *iambŷkē* and in two late lexica we have *zambŷkē*, probably renderings a foreign word starting with something sounding like *zh*. However, in the Greek and Latin literature the *zambŷkē/sambūca* was a stringed instrument. The instrument is said to have been fitted with short strings and looked like a Roman 'siege engine' (Ath. 633f; Aristid. Quint. p. 85. 10, who comments on its feminine and ignoble sound). (See West, M.L., *Ancient Greek Music*, Clarendon, Oxford 1992: 75-7). However, besides the string instrument, there was also a flute called *sambūca*, derived from the elder *sambucus*, in which the core is of soft pith which once removed gives a good bore propitious to the making of pipes or flutes. (See Manlius Severinus Boethius Anicius: *Fifth Book of Music*, translated by Paul Oscar, Georg Olms Verlag (1985), ISBN 3-487-04629-6.

10 Lawergren, B., Extant Silver Pipes from Ur. 2450 B.C. (2000), *Studien zur Archäologie II, ed. Hickmann, E., Eichmann, R., Deutches Archäologische Institut, Rahden, Leidorf*, pp. 121-132; Galpin, F.W., *The Music of the Sumerians...*, CUP, 1937, pp. 93-4. For a detailled treatise on flute making, see Forster, C.M.L., *Musical Mathematics, on the Art and Science of Acoustic Instruments*. (2000-2011) Chronicle Books, San Francisco.(www.chrysalis-foundation.org/flute_tone_holes.htm).

11 In an archaeomusicological context, polyphony is not a texture consisting of two or more independent melodic voices. It is an ensemble of different instruments, including singing and dancing, in some instances, playing together in the ignorance of any concept of harmony as we understand it today. There would have been occurences where notes of different pitches would have been played simultaneously, but they would not have been perceived as chords. See Marcetteau, M., A Queen's Orchestra at the Court of Mari: A New Perspective on the Archaic Instrumentarium in the Third Millennium B.C., in *ICONEA 2008, Proceedings of the International Conference of Near Eastern Archaeomusicology held at the British Museum, December 4, 5 and 6, 2008*, Dumbrill, R., and Finkel, I., Eds., pp. 67-76.

12 http://www.youtube.com/watch?v=4o4fH8z3jDQ

13 Lawson, G., Music, Intentionality and Tradition, in *Orient-Archäologie, Band 15, Studien zur Musikarchäologie*, Hickmann, Eichmann, Eds. (2004:61-97).

14 For a comprehensive list of instruments in the Ancient Near/Middle East, see Krispijn, T., Musical ensembles in ancient Mesopotamia, *ICONEA, proceedings of the International Conference of Neatr Eastern Archaeomusicology held at the British Museum.* (2008:125-150).

15 11/1-5 nīš *tuḫrim*; 12 7-5 *šēru*; 13/2-6 *išartu;* 14/1-6 *šalšatu*; 15/3-7 *embūbu*; 16/2-7 *rebūtu*; 17/4-1 *nīd qabli;* 18/1-3 *isqu*; 19/5-2 *qablītu*; 20/2-4 *titur qablītu*; 21/6-3 *kitmu*; 22 3-5 titur *išartu;* 23/7-4 *pītu*; 24/4-6 *serdû*.

16 See Chicago Assyrian Dictionary, *sub embūbu*. Note the absence of the 'm', the mimation, of *embūbu*. Mimation refers to the suffixed *-m* (the letter *mim* in many Semitic *abjads*) which occurs in some Semitic languages. This occurs in Akkadian on singular nouns. It was also present in proto-Semitic. Hence *embūbum*, written with a final 'm', the mimation is the Old Babylonian spelling; *embūbu* was the later orthography which by the first millenium, when CBS 10996 was written, had dropped the mimation. 17 or an interval placed on the third and seventh notes of a scale.

17 The text does not mention any instrument. This suggests that in other instances where string names alco appear, that they should be interpreted as elements of theory and not as organological description.

18 Krispijn, Th. Musical Ensembles in Ancient Mesopotamia, *ICONEA 2008, Proceedings of the Conference of Near Eastern Archaeomusicology held at the British Museum.* (2008:125-151). In the early lexical lists most chordophones (including the players and the songs they accompany) are denoted by the sign balaĝ 'harp' or componds with balaĝ. The lexical series E.D. Lu A of the Uruk IVa period (± 3200 B.C.) already includes gal balaĝ '(leading) harp player', and later lexical lists (Fara period ± 2600 B.C.) have balaĝdi 'singer of harp songs', balaĝ dilmun 'Dilmun harp', balaĝ mari 'harp/instrument of Mari', burbalaĝ '(player of a) special type of harp', and tigi (= NAR+BALAĞ literally 'harp of the singer'). The only other chordophone which could be included in the early lexical lists was gal.zà '(leading) lyre player' or 'singer of songs of praise' (?) (E.D. Lu A 108). zà follows gal šùd '(leading) prayer singer' and therefore could possibly be an abbreviation of zà.mí (zamin) 'lyre'. An objection against this suggestion is that zamin does not occur among musical instruments anywhere else in later lexical lists or literary texts of the 3rd millennium. It is only a word, written zà.me, meaning 'to be praised' or 'song of praise'; cf., zà.me = wādium 'someone who praises' (VE 1181). However, the etymology of zamin 'wide side' suggests an object like a musical instrument.

19 The bolong is at the same time a stringed, percussion and idiophonic instrument. A musician plays its strings, beats its membrane while a leaf of metal with rings inserted all round it, affixed to the top of its arm, rattles as a result of the playing of the strings and the beating of the membrane. The bolong is played by several peoples in West Africa, including Maninka, Fulbe, Senufo, Susu, and Kissi. It is a rare instrument. I would like to thank Mr. Sulaiman Camara, from Guinea Conakry, one of the rare players on the bolong, for his contribution (see http://www.youtube.com/watch?v=LtZiWtVrOVQ), and Lucie Durán from the School of Oriental and African Studies: *Dear Richard, well the word bolo in core Mande languages means hand, and bolon (bolong) means arm, can also mean an arm/branch of a river (as in the Gambie bolongo of Kunta Kinteh fame!) However, I have never enquired why the bolon should be called so; because it's like an arm? The other possibility is that it's onomatopoeic for the sound it makes. "Bato" means a bridge that sits in the middle of a round object.*

The kora bato is the bridge of the kora. There is no reason why the bolon should not have survived from the ancient world in West Africa - there are other similar survivals in Africa as you know (the lyre etc).

20 Etymology: 1552 (Pontus de Tyard, Solitaire premier dans ses Discours philosophiques, 14b, éd. 1587 cité par Vaganay ds Rom. Forsch., t. 32, p. 29); 1808 arg. appuyer sur la chanterelle (Hautel). Dér. de chanter*; suff. -erelle, forme allongée de -elle*. Fréq. abs. littér. : 16.

21 In musica il bordone è un effetto monofonico di accompagnamento in cui una nota suonati in modo continuo per buona parte o per l'intera composizione, sostenuti o ripetuti, e spesso determinano la tonalità della composizione stessa. L'uso del bordone ha origine nella musica antica dell'Asia di sudovest e si diffonde poi nell'India dell'est, nel nord e nell'ovest dell'Europa e nel sud dell'Africa. (van der Merwe 1989, p.11). Allo stesso tempo, un bordone è la parte di uno strumento musicale che produce delle note sostenute, generalmente senza una particolare attenzione dell'esecutore. Il sitar ed il sargam indiano sono strumenti ad arco capaci di eseguire dei bordoni.

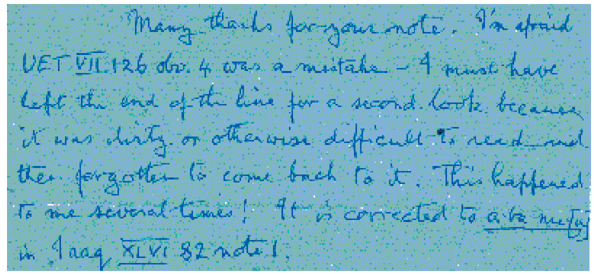
22 Dumbrill, R., *The Archaeomusicology of the Ancient Near East*, Pls. 229; 228; 227; 230; 236; 254; 250; 248; 225; 256; 247; 231; 249; 219.

23 It is possible to make educated estimations of frequency on lutes and other stringed instruments if the nature of the string is known. In the case of gut strings, the animal providing the intestines needs to be know: Sheep, pig, or cow since these are the most common. It is highly probable that for lutes, it was sheep gut that was used because cow's guts would have an appropriate mass, pig's would not have been used because of its mediocre quality. It is known that a string rings best closest to its breaking point therefore 80% of the breaking point would be an acceptable estimation. From this the frequency can be estimated with about 20-30% error, which is reasonbly adequate for an instrument over 4000 years old. My own experiments with Uruk-Akkadian lute replications give a chanterelle at 'A' 220Hz. It is impossible to say how the other, or the two other strings were tuned to each other. (See illustration top right.)

24 Hilprecht, H.V., *Mathematical and Chronological tablets from the Temple Library of Nippur*, Published by the Dept. of Archaeology, University of Pennsylvania (1906); Crickmore, L., The Tonal Systems of Mesopotamia and Ancient Greece: some Similarities and Differences. *ARANE*, Vol. I, (2009:1-16); Dumbrill, R., Four Tables from the Temple Library of Nippur: a Source for Plato's Number in Relation to the Quantification of Babylonian Tone Numbers, *ARANE*, Vol. I, (2009:27-39)

25 i) Inbal Shapira Lots and Lewi Stone, Perception of musical consonance and dissonance: an outcome of neural synchronization, Biomathematics Unit, Faculty of Life Sciences, Tel Aviv University, Ramat Aviv 69978, Israel, in J. R. Soc. Interface (2008) 5, 1429–1434 doi:10.1098/rsif.2008.0143, Published online 11 June 2008. ii) Gavin M. Bidelman and Ananthanarayan Krishnan, Neural Correlates of Consonance, Dissonance, and the Hierarchy of Musical Pitch in the Human Brainstem. Department of Speech Language, Hearing Sciences, Purdue University, West Lafayette, Indiana 47907-2038. in The Journal of Neuroscience, October 21, 2009 • 29(42):13165–13171 • 13165.

26 The tablet appears in Ur Excavations Texts. Publications of the joint expedition of the British Museum and of the University Museum of the University of Pennsylvania, Philadelphia, to Mesopotamia. Volume VII, Middle Babylonian Legal Documents and other Texts. Oliver R. Gurney. Note the lacuna in l.4, col. 2 which was later corrected in *IRAQ* XLVI 82, note 1. Professor Gurney writes back to me on this matter on the 15th April 1996:


Many thanks for your note. I'm afraid UET VII 126 obv. 4 was a mistake – I must have left the end of the line for a second look because it was dirty or otherwise difficult to read and then forgotten to come back to it. This happened to me several times! It is corrected to [illegible] in Iraq XLVI 82 note 1.

This text has been published at length. For an overview and comprehensive bibliography see Dumbrill, R, AANE 2005:27-36.

UET VII 126 = *nabnitu* XXXII:

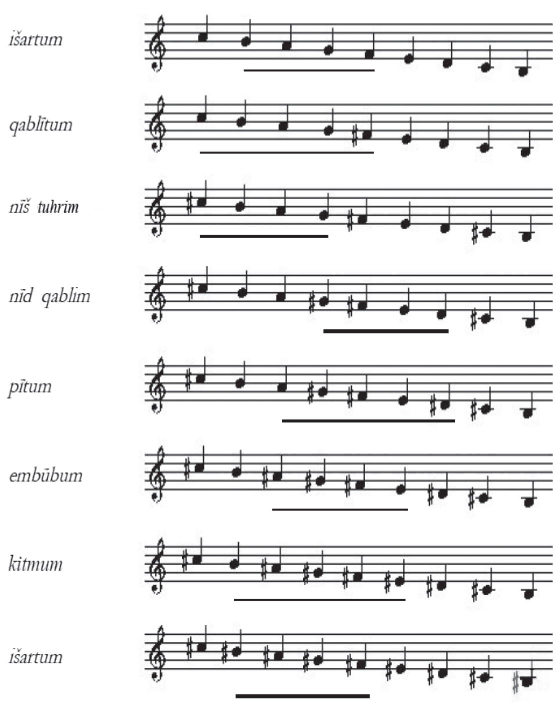
l.1 String-first front/fore (string)
l.2 String-second second
l.3 String-three-string-thin third, thin
l.4 String-four-small Ea-creator
l.5 String-five fifth
l.6 String-four of the behind fourth behind
l.7 String-three of the behind third behind
l.8 String-two of the behind second behind
l.9 [String-one] of the behind one behind
l.10 [Nine] string nine string

27 In the *CAD*, the string instrument for which a string nomenclature is listed, is dogmatically tyranslated as 'harp' although a) no instrument either in Sumerian or in Babylonian is mentioned and b) we have no conclusive term to equate to either hap, lyre or lute. This is a misleading translation.

and UET VII 74:

0 *[šum-ma* ^{giš}ZÀ.MÍ *pi-i-tum-ma]*
1 *[e-e]m-b[u-bu-um la za-ku]*2 *ša-al-š[a-am qa-at-na-am tu-na-sà-aḫ-ma]*
3 *e-em bu-bu-u[m iz-za-ku]*
4 *šum-ma* ^{giš}Z]À.MÍ *e-em-bu-bu-um-ma]*
5 *ki-it-mu-um [la za-ku]*
6 *re-bi úḫ-ri-im [tu-na-sà-aḫ-ma]*
7 *ki-it-mu-um i[z-za-ku]*
8 *šum-ma* ^{giš}ZÀ.MÍ *k[i-it-mu-um-ma]*
9 *i-šar-tum la za-[ka-at]*
10 *ša-mu-ša-am ù-úḫ-ri-a-a[m tu-na-sà-aḫ-ma]*
11 *i-šar-tum iz-za-[ku]*
12 *nu-su-ḫ[u-um]*
13 *šum-ma* ^{giš}ZÀ.MÍ *i-šar-t[um-ma]*
14 *qa-ab-li-ta-am ta-al-pu-[ut]*
15 *ša-mu-ša-am ù-úḫ-ri-a-am te-[ni-e-ma]*
16 $^{[giš]}$ZÀ.MÍ *ki-it-mu-[um]*
17 *[šum]-ma* ^{giš}ZÀ.MÍ *ki-it-m[u-um-ma]*
18 *[i-ša]r-ta-am la za-ku-ta-am t[a-al-pu-ut]*
19 *[re-bi] úḫ-ri-im te-ni-e![-ma]*
20 $^{[giš}$ZÀ.MÍ *e-em-bu-bu-um]*

28 Thetic disposition of scales.



29 Hagel, S., *in Musical traditions in the Middle East: Reminiscences of a distant past : A conference on ancient and modern Near East musicology.* Leiden University, The Netherlands Thursday 10 December 2009 to Saturday 12 December 2009. (Forthcoming)

30 THÉORÈME XVIII. — Les parhypates et les trites ne partagent pas le pycnum en parties égales. En effet, soit B une mèse, G une indicatrice, D une hypate. A partir de B, relâchons d'une quinte en Z, Z-D sera donc un ton. A partir de Z, surtendons d'une quarte en E. L'intervalle BE sera donc un ton, ainsi que G-E. Ajoutons l'intervalle commun D-G;Z-G sera donc égal à D-E; or, Z-E est une quarte; donc aucun son moyen ne peut tomber en proportion dans l'intervalle Z-E, car cet intervalle est superparticulier. De plus le (rapport) D-Z est égal au rapport G-E [lequel est aussi superparticulier] ; donc, aucun (rapport) moyen ne tombera dans l'intervalle D-G, lequel va de l'hypate à l'indicatrice. Donc la parhypate ne partage pas le pycnum en parties égales. Il en est de même de la trite.

31 The sources for Greek music and music theory are as follows:

Classical period:

- Clay epinetron (knee-guard for sewing) with black-figure painting by the Sappho Painter showing a trumpeting Amazon and the syllables TOTĒ TOTOTE apparently representing the notes sounded. Eleusis Museum 907, early 5th century B.C.

- Euripides, *Orestes* 140-207. Scraps of information on the music of this lyric dialogue from two sources: (i) Dionysius of Halicarnassus, *Comp.* 63f., makes a number of statements on the relative pitches of syllables in lines 140-2, which must apply also to the corresponding words in the antistrophe at 153-5. (ii) The scholiast on line 176 says 'this song is sung on the top notes and is very high'. The singers were men playing female roles.

- Euripides, *Orestes* 338-44: fragmentary score in Vienna papyrus G 2315 (Rainer inv. 8029), copied c.200 B.C.

- Euripides, *Iphigeneia in Aulis* 784-92 and 1499(?)-1509: fragmentary scores in Leiden papyrus inv. 510, copied in the 3rd century B.C. (excerpts; 1499(?)-1509 precedes 784-92; only in the latter passage can any of the notes be made out). The play was first produced in 405, a year after the poet's death in Macedon, by his son, Euripides the younger, so it may be that it fell to the latter to compose the music.

Late Classical or Hellenistic period:

- Two very small fragments of vocal notation, apparently from examples in a treatise: PHib. 231, copied in the mid-3rd century B.C.

- Fragment from a tragedy (?): Zenon papyrus 59533, copied in the mid-3rd century B.C.

- Fragments from tragic and satyric drama (?): Vienna papyrus G 29825 a-fs copied *ca..* 200 B.C. It is uncertain how many different pieces of composition are represented.

- Fragments of poetic text, parts of which arc provided with vocal notation: *POxy.* inv. 89B/29-33, copied 3rd-2nd century B.C.

- Fragment of hexameter hymn to Asclepius with notation for first line only: inscription from precinct of Asclepius at Epidaurus. *SEG* 30390. Inscribed about the late 3rd century A.D., but the composition, like several others from this site inscribed ai the same period, may be many centuries older.

Later Hellenistic Period:

- Athenaeus, Paean: substantial fragments of a choral work performed at Delphi in 127 B.C. by the Athenian Tecknitai, a company of professional musicians, and inscribed on an external wall of the Athenian Treasury at Delphi. Delphi Museum, inv. 517, 526, 494, 499.

- Limenius, Paean and processional: substantial fragments of a work similar to 10, performed on the same occasion and inscribed beside it. Delphi Museum, inv. 489, 1461, 1591, 209, 212, 226, 225.224,215,214.

- Fragments of a vocal text or texts: inscribed blocks from a sanctuary of the Carian deity Sinuri near Mylasa, probably 1st century B.C. The text extends over many lines, but not a single complete word is preserved.

Roman period:

- Song of Seikilos: inscribed stele from Aidin near Tralles (Caria, like 12). Copenhagen, National Museum, inv. 14897, commonly dated to the 1st century A.D.

- Invocation of the Muse, transmitted in MSS with songs of Mesomedes, but differing from them in dialect and (it may be felt) in musical style. The MSS give no indication of authorship; the dialect points to Ionian origin.

- Mesomedes, invocation of Calliope and Apollo: MS transmission. Mesomedes was a noted citharode and composer of Cretan origin, a courtier of Hadrian.

- Mesomedes, hymn to the Sun: MS transmission.

- Mesomedes, hymn to Nemesis: MS transmission (the music only in one MS).

- Three further pieces by Mesomedes, though now transmitted without musical notes, are accompanied by scholia which state the key of the music. In Heitsch's edition they are poems 4 (Lydian), 5 (Hypolydian), and 7 (Lydian). But the accompanying descriptions of the metres do not altogether accord with the metres of the poems; the scholium on 7, at least, seems to have attached itself to the wrong poem, and the same may be true of that on 4.

- Six elementary instrumental exercises, preserved in Anon. Bellerm. 97-104.

- Fragment of a satyric drama (?): *POxy.* 2436, copied in the 1st or 2nd century A.D. The poetic text might be old (though satyr-plays were still written in the 2nd century A.D.), but the music is in the later style.

- Dramatic recitative: Oslo papyrus inv. 1413 fr. a, 11.1-15, and frs. *b-e* copied in the late 1st or 2nd century A.D.

- Speech from a drama about Philoctetes: same papyrus, fr. *a* 15-19 and frs.*f-m.*

- Dramatic dialogue on the return of Orestes: Michigan papyrus inv. 2958,11. 1-18, copied in the 2nd century A.D.

- Fragment of obscure content: same papyrus, 11. 20-7.
- (a-e) Fragments of obscure content: POxy. 3704, copied in the 2nd century A.D. It is not clear whether more than one composition is represented.
- Fragments of uncertain content: *POxy*. inv. 102/5 8(c)↓ and 105731(c), copied in the 2nd century A.D.
- Others: *POxy*. inv. 63 6B 63/K(l-3)(b)→, 72.13(g)→, and 100/122(c), copied in the late 2nd or early 3rd century A.D.
- Fragmentary paean: Berlin papyrus inv. 6870,11.1-12, copied in the later 2nd or early 3rd century A.D. (on the verso of a document dated to 156 A.D.
- Fragmentary instrumental piece: same papyrus, 11.13-15.
- Fragment of a dramatic lament on the death of Ajax: same papyrus, 11.16-19.
- Fragmentary instrumental piece: same papyrus, 11. 20-2.
- Fragment of dramatic(?) lament: same papyrus, 1. 23.
- Dramatic fragments concerning Thetis and Achilles: *POxy*. 3161 recto, copied in the 3rd century A.D.
- Fragments of lament involving Persians and Lydians same papyrus, verso.
- Fragment of uncertain content: *POxy*. 3162, copied in the 3rd century A.D.
- Fragment of a tragic(?) verse with four alternative musical settings: *POxy*. 3705, copied in the 3rd century A.D.
- Fragments of uncertain content: *POxy*. inv. 100/81(b) and 100/125(a)↓, copied in the 3rd century A.D.
- Fragmentary Christian hymn: *POxy*. 1786, copied in the later 3rd century A.D.

32 *pitu* A (*pitu*) s.; 1. break, opening, breach, 2. opening ritual, opening ceremony. pitu C s.; (a musical term); OB, SB, NB. 7,4 SA *pi*(text GAD)-*tum* Studies Landsberger 266f. CBS 10996 i 9 (NB), cf. ibid, i 23, see also Iraq 30 229 right col. before line 1 (OB); *siḫip pi-t[im]* paired node JCS 48 52 ii' 9' (OB), also ibid. r. ii 3'; 5 *ḫansu* GIM *pi-tu* Iraq 46 73:8; [. ..] 2 ki.min (= *šiṭru*) *ša pi-i-te* URI.KI two songs [...], of *p*., Akkadian KAR 158 viii 15 (SB catalog of songs); [. . .] 4 GABA.MEŠ *ša pi-i-te* ibid. 48.

34 Forthcoming.

34

Lines	Akkadian numbers and names	Translation
11	1-5 *nīš tuḫri*	rise of the equiivalent
12	7-5 *šēru*	song
13	2-6 *išartu*	normal, erect
14	1-6 *šalšatu*	third
15	3-7 *embūbu*	reed-pipe
16	2-7 *rebūtu*	fourth
17	4-1 *nīd qabli*	fall of the middle
18	1-3 *isqu*	lot/portion
19	5-2 *qablītu*	middle
20	2-4 *titur qablītu*	bridge of the middle
21	6-3 *kitmu*	closing
22	3-5 *titur išartu*	brirge of the normal
23	7-4 *pītu*	opening
24	4-6 *serdū*	lament

35 Kilmer, A., The Cilt Song with Music from Ancient Ugarit: Another Interpretation. *Revue d'Assyriologie*, 68-1974.

36 Gurney, O.R., An Old Babylonian Treatise on the Tuning of the Harp, IRAQ XXX, (1968), 229-233; Babylonian Music Again, IRAQ LVI, (1994), 101-106.

37

notes	1	2	3	4	5	6	7	8	9	10	11	12	13
1.11	1>				5								
1.12					5<		7						
1.13		2>				6							
1.14						6<		8					
1.15			3>				7						
1.16							7<		9				
1.17				4>				8					
1.18								8<		10			
1.29					5>				9				
1.20									9<		11		
1.21						6>				10			
1.22										18<		12	
1.23							7>				11		
1.24											11<		13

38

1	8.640.000 *A-AN*[5]	25	518.000
2	6.480.000	27	480.000
3	4.320.000	30	432.000
4	3.240.000	32	405.000
5	2.592.000	36	360.000
6	2.160.000	40	324.000
8	1.620.000	45	288.000
9	1.440.000	48	270.000
10	1.296.000	50	259.000
12	1.080.000	54	240.000
15	864.000	60	216.000
16	810.000	64	202.500
18	720.000	72	180.000
20	648.000	[80	162.000]
24	540.000	[81	160.000]

39 Also found in Elamite mathematical texts. Bousquet, M., forthcoming.

40 Coburn, J., A New Interpretation of the Nippur Music-instruction Fragments. *JCS* 61 (2009)

41 Waerzeggers, c., and Siebes, R., *N.A.B.U.*, (2007), no.2 (juin), pp. 43-45.

42 Horowitz, W., JANES, Vol. 30, 2006.

43 Hilprecht, H.V., *Explorations in Bible Lands*, 1903, Holman, A.J., and Company, Philadelphia.

44 In general, a heptagram is any self-intersecting heptagon (7-sided polygon). There are two regular heptagrams, labeled as {7/2} and {7/3}, with the second number representing the vertex interval step from a regular heptagram, {7/1}. This is the smallest star polygon that can be drawn in two forms, as irreducible fractions. The two heptagrams are sometimes called the heptagram (for {7/2}) and the great heptagram (for {7/3}).

45 In the history of ancient Greece, the Orientalizing period is the cultural and art historical period informed by the art of Anatolia, Syria, Assyria, Phoenicia and Egypt, which started during the later part of the 8th century B.C. It encompasses a new, Orientalizing style, spurred by a period of increased cultural interchange in the Aegean world. The period is characterized by a shift from the prevailing Geometric style to a style with different sensibilities, which were inspired by the East. The intensity of the cultural interchange during this period is sometimes compared to that of the Late Bronze Age.

Further reading in neurology

Bergelson, E., Idsardi WJ (2009) A neurophysiological study into the foundations of tonal harmony. *Neuroreport* 20:239 –244.

Brattico, E., Tervaniemi, M., Peretz, I., (2006) Musical scale properties are automatically processed in the human auditory cortex. *Brain Res* 1117:162–174.

Burns, E.M., (1999) Intervals, scales, and tuning. In: *The psychology of music*, Ed 2 (Deutsch D, ed), pp. 215–264. San Diego: Academic.

Burns, E.M., Ward, W.D., (1978) Categorical perception—phenomenon or epiphenomenon: evidence from experiments in the perception of melodic musical intervals. *J Acoust Soc Am* 63:456–468.

Cariani, P.A., Delgutte, B., (1996a) Neural correlates of the pitch of complex tones. I. Pitch and pitch salience. *J Neurophysiol* 76:1698 –1716.

Ebeling, M., (2008) Neuronal periodicity detection as a basis for the perception of consonance: a mathematical model of tonal fusion. *J Acoust Soc Am* 124:2320 –2329.

Fishman, Y.I., Volkov, I.O., Noh, M.D., Garell, P.C., Bakken, H., Arezzo, J.C., Howard, M.A., Steinschneider, M. (2001) Consonance and dissonance of musical chords: neural correlates in auditory cortex of monkeys and humans. *J Neurophysiol* 86:2761–2788.

Houtsma, A.J., Goldstein, J.L., (1972) The central origin of the pitch of complex tones: evidence from musical interval recognition. *J Acoust Soc Am* 51:520 –529.

Kameoka, A., Kuriyagawa, M., (1969a) Consonance theory part I: consonance of dyads. *J Acoust Soc Am* 45:1451–1459.

Kameoka. A., Kuriyagawa, M., (1969b) Consonance theory part II: consonance of complex tones and its calculation method. *J Acoust Soc Am* 45:1460 –1469.

McKinney, M.F., Tramo, M.J., Delgutte, B., (2001) Neural correlates of the dissonance of musical intervals in the inferior colliculus. In: *Physiological and psychophysical bases of auditory function* (Breebaart DJ, Houtsma AJM, Kohlrausch A, Prijs VF, Schoonhoven R, eds), pp 83–89. Maastricht, The Netherlands.