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The *aulos sŷrinx*

> Αὐτίκα Τηλεφάνης ὁ Μεγαρικὸς οὕτως ἐπολέμησε ταῖς σύριγξιν ὥστε τοὺς αὐλοποιοὺς οὐδ᾽ ἐπιθεῖναι πώποτ᾽ εἴασεν ἐπὶ τοὺς αὐλούς, ἀλλὰ καὶ τοῦ Πυθικοῦ ἀγῶνος μάλιστα διὰ τοῦτ᾽ ἀπέστη.
>
> (Aristox. *ap*. Ps. Plut. *Mus*. 1138a)

> At any rate, Telephanes of Megara fought so harshly against the *sýringes* that he never even allowed the *aulos*-makers to add them to [his] *auloi*, but preferred to stay away from the Pythian Games mainly for this reason.

The aulete Telephanes was not some traditionalist oddball, worth an anecdote for lagging behind the music of his time, while anyway unable to compete with its star performers. In the passage quoted above he is favourably mentioned among undoubted authorities who would not embrace all kinds of musical style just for the sake of applause, in a chain of examples bolstering Aristoxenus' claims of musical quality through conscious restraint. Now, Aristoxenus' approval might not necessarily testify to public acceptance (though the sentence-initial αὐτίκα might be taken as indicating that the reported fact was commonly known); but Telephanes was among the instrumentalists hired to accompany the competing choruses at the Athenian Dionysia, and at the Athenian court Demosthenes would not hesitate to call this foreigner "worthiest of men" (ἀνδρῶν βέλτιστος), obviously without anticipating any negative reaction from the judges.[1] His tomb, purportedly erected by the Macedonian queen Cleopatra, was among the two most noteworthy ones when one reached Megara from the direction of Corinth.[2] His epitaph, finally, celebrates Telephanes as the very pinnacle of his art; even if we consider the demands of the genre, still we must assume that the claim did not appear outright ridiculous:

> Ὀρφεὺς μὲν κιθάρᾳ πλεῖστον γέρας εἵλετο θνητῶν,
> Νέστωρ δὲ γλώσσης ἡδυλόγου σοφίῃ,
> τεκτοσύνῃ δ᾽ ἐπέων πολυίστωρ θεῖος Ὅμηρος,
> Τηλεφάνης δ᾽ αὐλοῖς, οὗ τάφος ἐστὶν ὅδε.
>
> ('Nicarchus', *Anth*. *Pal*. 7, 159)

[1] Demosth. *In Midam* 17.
[2] Paus. 1, 44, 6.

Orpheus has earned highest honour among men with the lyre.
Nestor with the art of the sweet-talking tongue,
With architecture of words, much-learned divine Homer,
Telephanes with the auloi: this is his tomb.

Obviously in the middle of the fourth century the functional extensions of *auloi* called *sýringes* could still be seriously challenged. The verb ἐπολέμησε, "waged war", implies that Telephanes did not regard the question of having or not having them as a matter of mere personal preference, but rejected them with a kind of missionary zeal. On the other hand, the expression οὕτως … ὥστε οὐδ' ἐπιθεῖναι πώποτ' εἴασεν, «in such a way … that he never even allowed to add», bluntly indicates that in general one would have expected a professional aulete to own some instruments with *sýringes*, even if, in principle, he opposed to their use. The reason for that becomes immediately clear: having no *sýringes* at all meant being unable to compete at the Pythian Games, a major opportunity to win fame and riches.[3] Telephanes may have had other reasons for not performing there as well; at any rate, as Aristoxenus sees it, he gave a strong testimony by being entirely prepared to pay for his convictions.

It is commonly accepted that the reason why competing at Delphi required having *sýringes* is to be found in the nature of the *nómos Pythikós*, a set piece to be performed there, which portrayed Apollo's fight with the dragon by musical means. One of its parts bore the name *sýringes* or *sýrigma*:[4]

… σύριγγας δὲ τὴν ἔκλειψιν τοῦ θηρίου, μιμουμένων ὡς ἂν καταστρέφοντος ἐσχάτους τινὰς συριγμούς.

(Strab. 9, 3, 10)

…and *sýringes* [indicating] the expiring of the beast, in imitation of some sort of last squeaks (*syrigmoús*) of it dying.

Thus the common inference seems more than likely: this programmatic piece of music, '*sýringes*' imitating *syrigmoí*, was associated with the instrument's device called *sýringes*.

[3] The text clearly says that Telephanes' rejection of the *sýringes* was the reason why he did not participate in the Pythian games. I do not understand how BECKER (1966, p. 71) arrives at the interpretation «da es auch für den Pythischen Agon besser sei, wenn sie fehle». HOWARD (1893, p. 34) assumes that the *sŷrinx* did not open new possibilities, but merely facilitated playing; but if Telephanes would just have boasted his ability to do without it, why should he have avoided to display his skills at the games?

[4] Cfr. also *Hypoth.* in Pind. *Pyth. schol.* a: σύριγμα δὲ διὰ τὸν τοῦ ὄφεως συριγμόν.

So what were those *sýringes*? The word '*sŷrinx*' is best known as the Greek name for the panpipe, made of a row of tubes without holes. It could also denote a flute with a single duct, equipped with finger holes (σῦριγξ μονοκάλαμος).[5] Apart from its musical meanings, the term would serve for any cylindrical duct, or perhaps any duct with parallel walls – apparently a secondary acceptation derived from the flute.[6] There can hardly be any doubt that panpipes and flutes were older than some optional refinement of the *aulos*.

Its association with the flute indicates that the stem συριγ- typically implied qualities of sound generated by a turbulence of air, for instance when blown over an edge, potentially including an element of hissing as well as high pitch. This is confirmed not only by the application to the dying serpent, and snakes in general,[7] but also by the verb συρίττειν/συρίζειν and its nominal cognates on -μός and -μα, whose semantics range from the sound of wind to catcalls in the theatre.[8]

Telephanes' rejection of the *sŷrinx* indicates that the sound of the *aulos* with *sŷrinx* differed from the 'normal' sound of an *aulos* in a potentially irritating way; the fact that it was used to portray a monster's death pangs points in a similar direction. For the general idea of συριγ- falling short of the classical ideal of musical sound compare the ancient discourse about the phoneme /*s*/ in song. That its sound fell within the semantic range of συρίττειν plainly emerges from its description in Plato;[9] its potentially unpleasant effect, which obviously consists in a disruption of the continuity of a voiced, hence pitch-bearing, stream of performed text,[10] was (if the sources are to be trusted) experimentally avoided as early as around 500 BC in 'asigmatic' compositions. Pindar mentions

[5] Cfr. Euphorion *ap*. Athen. 184a; *schol*. Opp. *Hal*. 1, 565.

[6] -ιγξ as a suffix came to be associated especially with musical instruments, cfr. φόρμιγξ, σάλπιγξ, φῶτιγξ.

[7] Cfr. Aristot. *Hist. an*. 536a.

[8] Cfr. LSJ *s.v*.

[9] Plat. *Theaet*. 203b: τό τε σῖγμα τῶν ἀφώνων ἐστί, ψόφος τις μόνον, οἷον συριττούσης τῆς γλώττης "the sigma also is one of the voiceless, a mere noise, such as if the tongue would hiss (*syríttein*)".

[10] Ancient theoretical reflection was systematised by Aristoxenus (Dion. Halic. *Comp*. 14). All other ancient Greek non-occlusives were voiced. Unvoiced occlusives, on the other hand, most often served as syllable onsets, which do not consume noticeable time; in the comparatively few cases where they close a syllable and are thus responsible for an additional mora, the unvoiced time span would at least be filled by a minimal period of silence, not noise as in the case of /*s*/. On top of this, it was possible that in relatively slow song a higher continuity of voicing was achieved by practically splitting the closed syllable into two open ones, introducing a secondary vowel: cfr. πετέρας for πέτρας in the inscribed hymn DAGM nr. 20, 5, with the two ε even set to different notes.

previous performances in which the letter 'σ' sounded 'κίβδηλος', 'contaminated by admixture of a less valuable material', obviously comparing 'clean' sound with precious substances.[11] Aristoxenus confirms the avoidance or cautious use of sigma by poets on a broader basis, and so does Dionysius of Halicarnassus, in a chapter where he draws upon earlier sources.[12] In the same passage the *syrigmós* of the spoken /*s*/ is eventually associated with sounds of beasts rather than rational beings,[13] which is so evocative of the dying-serpent *syrigmós* that a relation of some kind between the two discourses must be acknowledged.

When playing the *aulos*, how could such a dramatic shift to a very different quality of sound be achieved? As early as in 1893, Albert A. Howard suggested that the *sŷrinx* was in fact a 'speaker hole', designed to enable or facilitate overblowing, i.e. switching from the low basic register to a higher register.[14] This hypothesis was based mainly on a couple of passages that associate the device of the *sŷrinx* with a raise in pitch (we are going to look at them below). At Howard's time, there was not much archaeological evidence available in order to support the speaker-hole theory, although he was able to point to a small hole in one of the pipes from Pompeii he had studied. Since then, his ideas have been challenged especially by Heinz Becker, whose book published in 1966 is still influential, at least in the German-speaking world. Andrew Barker among others accepted Howard's interpretation as likely, while Martin L. West, in his groundbreaking handbook, did not advocate any definitive interpretation.[15] In the following pages I will try to substantiate Howard's theory beyond reasonable doubt, and to solve some of the remaining problems along the way, on the basis of close readings of texts as well as archaeological evidence.

The *nómos Pythikós* was traditionally attributed to Sacadas and thus dated back to the early sixth century. And yet, thanks to the cliché about the musical innovations of the late fifth and early fourth centuries and the more traditionalist reaction to it, a cliché nourished mainly by Plato, Aristoxenus and comedy, I guess that most of us would instinctively prefer to allocate Telephanes' story within this chronological scheme, rather

[11] Dion. Halic. *Comp*. 14; Athen. 455c. Cfr. D'Angour 1997; Porter 2007; on asigmatism and sigmatism in general, also Clayman 1987.

[12] Aristox. *ap*. Athen. 467a; Dion. Halic., *l. c*.

[13] Cfr. also Plat. *Leg*. 669e. On the citharistic *syrigmós*, generally assumed to be an imitation of the auletic technique, cfr. Barker 1982.

[14] Howard 1893, pp. 32-35.

[15] Barker 1981, pp. 52, n. 17; 226, n. 137; West 1992, pp. 86; 102 s.

than imagine that he opposed an element that had already been there for two centuries. The text does not help us to decide between the two options. In his chain of examples, designed to prove that both in modern and ancient compositions the observed renouncement of a particular feature does not imply ignorance on part of the composers but, rather, often indicates a deliberate choice, Aristoxenus quotes elements that he considered undeniably archaic just as well as innovations of the fourth century.

We have seen that Telephanes' objection was likely directed against the musical employment of a type of sound that was perceived as aesthetically inferior. This resonates with two comic fragments that are related to the 'New Music' (as we usually call it) of the late Classical period. One consists in two and a half lines quoted by Pseudo-Plutarch shortly after the famous Pherecrates fragment, where Music describes her maltreatment by modern poets, culminating in Timotheus. The additional lines are most often understood as its continuation, although following this reading it is very difficult to make sense of the intervening sentence (unfortunately corrupted in itself), in which the text switches from quoting Pherecrates to Aristophanes, and from Timotheus as the target of ridicule to his colleague Philoxenus. The two quotations are linked by the fact that both are spoken by a personified Music and are similar in content. On the other hand, the picture of spoilt vegetable used in the latter does not fit ideally with the sexually loaded charges of the former, and although the latter can be construed as continuing the former, it is doubtful whether its accusatives, which seem to belong exclusively to the sphere of the audible, complement the dressing imagery well:

> ...κἂν ἐντύχῃ πού μοι βαδιζούσῃ μόνῃ
> ἀπέδυσε κἀνέδυσε χορδὰς δώδεκα
> — […] —
> ἐξαρμονίους ὑπερβολαίους τ᾽ ἀνοσίους
> καὶ νιγλάρους, ὥσπερ τε τὰς ῥαφάνους ὅλην
> καμπῶν με κατεμέστωσε.
>
> (Ps. Plut. *Mus*. 1142a)

> … and whenever he encountered me walking on my own
> he undressed me and dressed me in twelve strings
> — […] —
> exharmonic, and in impious extra-high-pitched,
> and whining, and like a cabbage he
> filled me all over with wrigglings.

On balance, there is considerable probability that the author of the dialogue has added another comical fragment in order to bring Philoxenus

in the text, who was second in fame only to Timotheus, but is conspicuously missing from Pherecrates' account. In any case, it is one of the foremost composers of 'New Music' who is here associated with ὑπερβολαῖοι, notes of untraditionally high pitch, and νίγλαροι – probably some kind of non-melodic effect, possibly also related to high pitch.[16]

The second text concerns Timotheus, and more specifically his style of *aulos* music, if we trust the introductory statement in Athenaeus:

> χηνίζειν δὲ εἴρηται ἐπὶ τῶν αὐλούντων. Δίφιλος Συνωρίδι·
> ἐχηνίασας· ποιοῦσι τοῦτο πάντες οἱ
> παρὰ Τιμοθέῳ.
>
> (Diph. *ap*. Athen. 4, 657e)
>
> The term 'goosising' is used for *aulos* players. Diphilos in the *Synoris*: "You've goosised! That's what they all do, those followers of Timotheus.

The reference to the sound of geese once more leaves no doubt that reference is made to effects that were introduced and used deliberately, but not for the purpose of pleasurable sound. But which characteristic of the bird's cackle is the one that invoked the comparison? Geese, more specifically members of the species *Anser anser*, the greylag goose and the domesticated forms derived from it, typically produce harsh intermittent calls of little musical quality. These would differ little from the cawing and croaking of other birds, were it not for characteristic interspersed squeaks, where the voice suddenly, and only for a fraction of a second, breaks into a much higher pitch range, producing a sound that is much more clearly pitched, only to return immediately to its normal mode.[17]

All this is circumstantial evidence, but it points in the same direction: associated with the most celebrated names of late Classical avant-garde

[16] The term is not well attested. Its explanation in the *scholia* and lexica as κροῦμα παρακελευστικόν (Suda, *s.v.*; *schol*. Aristoph. *Acharn*. 554) is apparently derived from Eupolis, fr. 110 Kock (τοιαῦτα μέντοι νιγλαρεύων κρούματα) and Aristoph. *Acharn*. 554 (αὐλῶν κελευστῶν νιγλάρων συριγμάτων) and thus of no additional value. More interesting is the definition as τερετίσματα (Hesych. *s.v.*; Suda), which in its most technical usage suggests embellishments by repetition of a note with staccato effects (τερετισμός: Anon. Bell. 2; 10; 92). If the plausible restoration of <νιγ>λαρούς in Athen. 44d is correct, this passage from the comic poet Phrynichus contributes associations of feebleness and whining (μινυρός), while the expression ἀηδόνων ἠπίαλος adds substance to the idea of a staccato element, which is a plausible result of nightingales shivering from ague. Cfr. further Rocconi 2003, pp. 34 f.; 85-87.

[17] Cfr. e.g. http://ibc.lynxeds.com/sound/greylag-goose-anser-anser/two-birds-calling-taking-flight (2011-04-26).

music, we find indications of the introduction (or at the very least an increasing usage) of sound effects incorporating an extraordinarily high pitch range and a shrill, squeaking timbre. These effects were not meant to produce a particularly pleasant sound; instead, they won public approval because of their startling novelty – which must always be contextualised in a culture which considered programmatic elements crucial for instrumental as well as vocal music. Such effects can hardly be produced on a lyre: although high harmonics can be created by stopping strings, the resulting sounds are exceptionally gentle, quite different from what we imagine in the quoted texts. Anyway, Diphilos' verses are explicitly associated with the *aulos*; and an overblown pipe can be just as penetrating as one might wish.

Thus it is more than likely that overblowing, in one way or another, was a regular ingredient of the professional auletic art. Here are the texts that led Howard to identify the *sŷrinx* as a device to facilitate the task: first, a passage by Aristoxenus in which he seeks to define the largest musical interval within which a melody can evolve, as opposed to intervals between different performers or instruments:

> τάχα γὰρ ὁ τῶν παρθενίων αὐλῶν ὀξύτατος φθόγγος πρὸς τὸν τῶν ὑπερτελείων βαρύτατον μεῖζον ἂν ποιήσειε τοῦ εἰρημένου τρὶς διὰ πασῶν διάστημα, καὶ κατασπασθείσης γε τῆς σύριγγος ὁ τοῦ συρίττοντος ὀξύτατος πρὸς τὸν τοῦ αὐλοῦντος βαρύτατον μεῖζον ἂν ποιήσειε τοῦ ῥηθέντος διαστήματος.
>
> (Aristox. *Harm*. 1, 20, pp. 26, 8 – 27, 3 Da Rios)

> The highest note of the girls *aulos* in relation to the deepest note of the oversize *aulos* would easily yield an interval that exceeds the mentioned three octaves; and if the *sŷrinx* is pulled down, the highest note of the *sŷrinx*-mode player (*toû syríttontos*) would exceed the named interval in relation to the deepest note of the *aulos*-mode player (*toû auloûntos*).

This text tells us that the *sŷrinx* was activated by 'pulling it down' (κατασπᾶν). Playing with or without it could be perceived as being so much different that two different verbs were appropriate: the sound of the *aulos* (αὐλεῖν), properly speaking, was its sound without the *sŷrinx* activated.

A passage from the Peripatetic treatise *On Sounds* employs the *sŷrinx* as an example of how the sound may become higher and thinner:

> παχεῖαι δ' εἰσὶ τῶν φωνῶν τοὐναντίον, ὅταν ᾖ τὸ πνεῦμα πολὺ καὶ ἀθρόον ἐκπῖπτον· διὸ καὶ τῶν ἀνδρῶν εἰσὶ παχύτεραι καὶ τῶν τελείων αὐλῶν, καὶ μᾶλλον ὅταν πληρώσῃ τις αὐτοὺς τοῦ

πνεύματος. φανερὸν δ' ἐστίν· καὶ γὰρ ἂν πιέσῃ τις τὰ ζεύγη, μᾶλλον ὀξυτέρα ἡ φωνὴ γίγνεται καὶ λεπτοτέρα, κἂν κατασπάσῃ τις τὰς σύριγγας. κἂν δὲ ἐπιλάβῃ, παμπλείων ὁ ὄγκος γίγνεται τῆς φωνῆς διὰ τὸ πλῆθος τοῦ πνεύματος, καθάπερ καὶ ἀπὸ τῶν παχυτέρων χορδῶν.

(Ps. Aristot. *De audib*. 804a)

Thick voices, by contrast, are those that occur when the breath is expelled as a large quantity massed together. That is why those of men and of *téleioi auloí* are thicker, especially when one fills them with the breath. This is clear; for if one compresses the pair of reeds, the sound becomes higher-pitched and thinner, as it does if one pulls down the *sýringes*: and if one closes them, the bulk of the sound becomes fuller because of the quantity of breath, just as it does from thicker strings (trans. A. Barker).

The manoeuvre of activating the *sŷrinx* is once more described as 'pulling down'; in addition, we learn that deactivating it implies an action of 'closing' or 'stopping' (ἐπιλαβεῖν), a term typically used for openings. In fact its lexical definition expressly defines the *sŷrinx* as a 'hole':[18]

σύριγξ· σημαίνει τὴν ὀπὴν τῶν μουσικῶν αὐλῶν καὶ πάθος καὶ τὴν δορατοθήκην.

(Herodian. *Pros. cath*. 1, 44, 5 Lentz; *Etym. Magn*. 736, 28)

sŷrinx denotes the hole of the musical auloi and a *páthos* and the spear-case.

A brief note may be useful in regard to the way in which a 'speaker hole' actually works. If the air column within the duct is incited to vibrate, several 'modes' of vibration are possible. Which one becomes dominant depends on several factors, in the *aulos* mainly on the flexibility and the opening of the reed and the pressure of blowing. Since the cylindrical duct of the *aulos* is effectively closed on one end by the reed, this end is constrained to become a node of the wave: a point where the

[18] Cfr. *Anecdota Graeca Oxoniensia*, ed. J.A. Cramer, 2, 409: σύριγξ· σημαίνει δ'· τὴν ὀπὴν τῶν μουσικῶν αὐλῶν καὶ τὸ πάθος καὶ τὴν δουρατοθήκην. BECKER (1966, p. 71 f.) criticises Howard and those accepting his theory for taking these definitions in the sense of "some hole" of the *aulos*, neglecting the definite article, and argues that '*the* hole' must be the exit of the main bore. In fact Becker is unaware of the typical language of the lexicon, where the definite article means 'the specific item, among those that would also be covered by the present loose definition, that is actually called by this name'; cfr. *e.g*. 1, 61, 5 Herodian. *Pros. cath*.: σημαίνει δὲ καὶ τὸ μέρος τῆς λαβῆς τοῦ ξίφους «it also denotes *the* part of the sword hilt», where there can be no doubt that there were more than one parts.

longitudinal flow of particles during vibration is theoretically zero, while pressure differences are maximal. On the other hand, the open end is an antinode, with maximal particle movement and zero pressure difference, due to the connection with the external air. Consequently the half-wavelength of the basic oscillatory mode, which generates the fundamental frequency and the lowest playing register, is twice the effective length of the tube (Fig. 1).

In order to produce notes of the second register, a small hole in the wall of the tube is opened, optimally at about one third of the effective tube length. Such a hole prevents positive or negative pressure from building up in its position, as pressure differences are compensated by the exchange of particles with external air. In this way, the fundamental oscillation, for which this position is close to a node and therefore requires high pressure differences, is destabilised. The second mode, in contrast, is not affected at all, since it has an antinode in this position, requiring no resistance to pressure, and consequently it takes over as the prevailing form of oscillation. As can be gleaned from igure 1, its wavelength is a third of that of the basic mode, so that the second register of the instrument gives the third harmonic, a perceived pitch an octave and a fifth above the first register.

Assuming that the *sŷrinx* was just such a kind of hole, the argument suggested in the quoted passage from *De audibilibus* becomes understandable. The author connects a 'thick' quality of sound with the expulsion of a (comparatively) large quantity of air in a massive flow. The first example, male voices, apparently presumes larger windpipes and/or amounts of breath in males as compared to females. The second, *téleioi auloí* as such, is not entirely clear: doubtless this kind of *aulos* was very long,[19] but we do not know whether it had also an exceptionally wide bore. In any case, the fact that these (and presumably other kinds also) sounded fuller when blown more vigorously is pretty obvious. The next example is familiar to players of reed instruments: squeezing the reed between the lips, thus decreasing its opening, results in higher pitch and lower volume – quite in accordance with the ancient author's explanation, which obviously targets the reduced stream of air that enters through the reduced orifice. Even though the effect is paralleled with that of the *sŷrinx* in what is introduced like an afterthought, it should not be taken for granted that what the author had first in mind was a change of register by reed manipulation.[20] True, such a technique of overblowing is

[19] Aristox. *ap*. Athen. 634f.
[20] So HOWARD 1893, p. 33.

possible and well known, but the passage is just as well understandable in terms of the small increase in pitch that results from the reduction of the reed's acoustical length effected by the reduction of its size. The *sŷrinx*, in contrast, would not reduce the amount of air that enters the instrument, but, in the eyes of the Peripatetic writer, let part of it escape early, so that less of it is eventually involved in the production of sound – and less tightly "massed together", a smaller quantity being distributed within a duct which is still of still the same size. Conversely, closing the *sŷrinx* brings with it a larger "quantity of breath", which only makes sense if the orifice to be closed is understood as a way of escape.

All this would contribute to a nice picture of a small hole with a cover to be pulled down for overblowing, were it not for a remark by Plutarch, which seems to turn the mechanism on its head:

> …καὶ διὰ τί, τῆς σύριγγος ἀνασπωμένης, πᾶσιν ὀξύνεται τοῖς φθόγγοις, κλινομένης δὲ πάλιν βαρύνεται.
>
> (Plut. *Non posse* 1096a-b)

> … and why it is that when the *sŷrinx* gets pulled up all the notes [of the *aulos*] become higher, while when it is tilted, they become lower again.

Unlike in Aristoxenus and Ps. Aristotle, the *sŷrinx* is here activated by pulling it up, not down. Of course, the implementation of the mechanism might have changed in the intervening centuries. But this is not as likely as it might seem at first glance. From the archaeological record we know of two distinct types of mechanism used to open and close the side holes of an *aulos*: rotating rings with a hole that could be aligned with a hole in the core, and sliders attached to rods, where the hole is covered by a moving plate.[21] The first type requires the operating finger to reach right to the ring and the small knob attached to it, which allows the player to turn it; the second type is only useful for holes located beyond – in the extant cases, below – the fingered part of the pipe. Howard's Pompeii example of a possible *sŷrinx*, which became interred during Plutarch's lifetime, features a turning ring. A tiny hole is drilled on the upper side of the instrument, in alignment with the finger holes, which seems the most natural thing to do, especially since in this way its knob would work in the exact same way as all the others (with the inevitable exception of the thumb hole). It is hard to envisage any reason why the inventors of a similar mechanism should have placed the hole on the underside or laterally.

[21] For a concise bibliography on *aulos* mechanism, cfr. HAGEL 2010a, p. 337, n. 28.

But such a type of *sŷrinx* could not be operated during playing, since it required the hand to move up close to the mouthpiece. What if a more common type, by chance missing from the record, used remote-operable sliders instead? Even if it did, this would hardly offer a plausible option for a design change: to open a hole, sliders are normally pulled towards the hand; otherwise the attachment of the rod would partially obstruct the opening. In addition, the normal way of playing was certainly with a closed *sŷrinx*, and for better fingering, one would preferably have the potentially irritating end of the rod out of the way, i.e., in this case, pushed upwards: therefore, the natural way of building such a – hypothetical! – mechanism would be to have the slider pushed upwards to shut the hole, with no possible motivation for change.

Finally, might the two different ways of referring to its opening represent the two types of mechanism? If so, Plutarch would have to mean the rotating ring, since the verb he uses for the action of closing, κλίνειν, cannot possibly denote a slider motion, while it makes good sense in the context of turning. This would leave the 'pulling down' of the earlier sources to the slider, in good accord with our general considerations (assuming, as I think is warranted, that 'down', if applied to the transversal dimension of the *aulos*, can only mean, 'towards the exit end'). So the two-mechanism hypothesis cannot easily be ruled out, and, who knows, it might once be verified by new material evidence.

Nevertheless I think the literary sources are also understandable without assuming that they describe different techniques at all. It suffices to acknowledge that it is not so obvious what exactly one would call 'the *sŷrinx*'. From a technical viewpoint, it is of course the hole, which alone has any acoustical effect. But one cannot literally pull a hole. From a more practical perspective, therefore, one might rather apply the term to the item that is actually manipulated, which is the knob that is soldiered to the ring at a right angle to the hole in the direction of the hand: if the hole is located on the upper side, the knob sits left on a left-hand pipe and right on a right-hand pipe (cfr. Fig. 2 from the left-hand Pompeii pipe that Howard describes).

If this knob is focussed as 'the *sŷrinx*', the terminology of the two older passages is completely natural: it is 'pulled down' in order to put the device in operation. When the speaker hole is closed, the knob is pushed at the position where the hole had been visible (Fig. 3); this is most aptly described by the term ἐπιλαβεῖν, which semantically draws attention to a means of closing just as well as to the aperture that is closed. If, on the other hand, the hole in the outer, visible layer of metal is addressed as 'the *sŷrinx*', it is in fact, and visibly, 'pulled up' when activated, and 'inclined' or 'turned aside', when deactivated.

In any case, activation involves 'pulling', -σπᾶν. The player's forefinger reaches out so that its tip comes to lie on top of the knob and pulls it, in the case of a left-hand pipe as in Figure 2 and Figure 3, in an anticlockwise motion (cfr. Fig. 4). The basic 'feel' of the action is therefore maintained in both ways of describing it, regardless of whether the result was perceived as something 'being pulled upwards' or 'pulling something downwards' (note that the indirect view, where the item handled is not identical with the subject of the verb, is only attested in passive voice, fittingly expressing the fact that the outer hole is drawn upwards although nobody acts on it directly; this may of course be coincidence).

The small hole on one of the Pompeii pipes was all the archaeological evidence Howard could point to.[22] Meanwhile a number of finds with more or less similar holes have come to light, although none featuring the mechanism that the Pompeii example demonstrates so nicely. I have collected most of these in Figure 5, with photographs printed to scale as exactly as possible from the available data. The holes that are candidates to be the openings called *sŷrinx* vary conspicuously both in size and position. Some of them are located above the 'bulb' and thus very close to the insert that accepts the reed, others a short distance below the bulb. The latter class holds only tiny holes, while there are two examples of unexpectedly large openings near the mouthpiece. One of these is found on the Reading *aulos*.[23] The parallel section between the bulb and the insert cone, where it sits, still shows remnants of its metal encasing. Therefore, it probably held a mechanism of the turning-ring kind (a sliding ring would equally be possible, but is so far unattested). If it did so, we cannot know how large the diameter of the opening actually was, since the hole in the ring might have been considerably smaller than that in the core. Particularly in the case of a small external hole, such an arrangement would make good sense, because it facilitates the handling: if the internal hole is just as small as the external, they must be aligned to the fraction of a millimetre; if, in contrast, the internal hole is larger, the effective opening will equal that of the external hole even if the ring is only roughly adjusted in a quick movement of the hand. The date of the Reading *aulos* is unknown, but there is little reason to assume that it is earlier than the Roman period.

[22] For corrected data and a new musical evaluation, cfr. HAGEL 2008a; HAGEL 2008b; HAGEL forthcoming.

[23] Cfr. LANDELS 1968, suggesting the function as a speaker hole (p. 234). I am grateful to Amy Smith, curator of the Ure Museum, for discussing this unique *aulos* with me, and allowing me to take photographs.

The bulb section from Delos was found in a context also implying Greco-Roman origin;[24] this pipe, however, can hardly have been supplied with a metal mechanism, since the hole is found on a curved surface. Of course it also cannot have always been entirely open; thus it was apparently stopped by other means, for instance with a plug of wax. In this way, it would have been easy to control the effective diameter by carefully pushing the wax back from the rim with the nail of the thumb.

Three finds have a small hole close to the mouthpiece, somewhere on the slopes of the gentle valley between the expansions of the bulb and the insert cone. Two undated items are stored in the National Museum of Taranto.[25] Both have tiny holes drilled at the base of the insert cone, slightly above a conspicuous mark that visually sets apart the final section of the instrument: in one case an incised line, in the other a ridge. The distances from the rim of the insert are 15.6 mm and 21 mm, respectively, the shorter distance belonging to the item with a much shorter bulb and a somewhat rudimentary cone, perhaps indicating a more archaic design.[26] To complicate the picture even further, the external resemblance of the pieces conceals different internal structures. In both fragments the reed insert is manufactured in a very similar way to other finds: the main bore first widens in a sudden step against which the reed can maximally be pushed, then slightly and smoothly expands up to the mouth end. Now on the fragment with the longer bulb, the small hole meets the main tube about a millimetre below the step, so that it cannot interfere with the reed. Even so, it seems that pains are taken to place it as close to the mouthpiece as possible. In the other, more archaic-looking piece, however, the hole enters the tube almost 8.5 mm above the step (which is unusually far removed from the end), right where we expect the stem of the double-reed to sit. Was its purpose here totally different from that of the other examples? There have been considerations that such holes might actually have received pins that held the parts together – in this case, that might have fixed the reed to the instrument. However, this is wholly impractical: any kind of glue or friction-enhancing matter, such as a winding of waxed thread would do the job better, and more so if only one pin would be involved. Certainly if a reed is prepared so that it fits into the tube in an air-tight connection, no additional means need

[24] Delos, Inv. B 5168: Deonna 1938, p. 324 f. with pl. 813.

[25] I express my gratitude to Antonietta Dell'Aglio, director of the National Archaeological Museum, for giving the permission to study the finds, and her team for their kind support.

[26] The typology of such parts was discussed by Stelios Psaroudakēs at the University of Reading, 2011-03-25, during the symposium "The *Aulos* in Ancient Greek Music".

be taken to secure it in place. Therefore I can at present suggest only one possible function for this awkward construction: the small hole would have been opened by pulling out the reed a bit, and closed by pushing it in. Indeed the remaining 15 mm are sufficient to hold the reed in place,[27] while the span of 8 mm below the small hole would comfortably serve for adjusting the reed position when tuning the instrument. On the other Taranto fragment, opening and closing would have to be done externally, for instance with a small plug of wax.

The same is true for an instrument from the Athenian Agora, where the small hole is further removed from the upper end of the instrument, so that it comes to lie on the bulb.[28] Of a wooden pair of *auloi*, now in the Egyptian Museum at Berlin,[29] one has its small holes on the other side of the bulb, the other high on the cylindrical main part of the tube. Note however that these are small instruments; as the possible – but by no means certain – reconstruction of the Athenian insert in Figure 5 shows, the absolute distances on the Berlin *aulos* may well have been smaller than or comparable with that on the large Agora *aulos*. Comparable to the Berlin *aulos* is a bone *aulos* from Paestum, dated to the first half of the fifth century BC. Also in this case the higher pipe has a small hole drilled through the bulb wall, the other through a thin cylindrical length below the bulb, the end of which was inserted in the highest section of the main tube.[30]

Finally, there is a possible example with ring mechanism from Meroë, located immediately below the broken-off bulb, just as on the pipe from Pompeii.[31] The interpretation of this hole as originally holding "a small metal rivet" is entirely unconvincing, as I have just argued, but I have not been able to examine the piece, and from the publication one cannot tell whether there was a turning ring.

The variety of sizes and placements of the holes even in so small a sample suggests that either these served different purposes or that they re-

[27] On Naples National Museum Inv. 76893, for instance, the complement of the Pompeii pipe discussed here, the insert depth can be determined exactly; it is 14.9 mm.

[28] Cfr. LANDELS 1964, suggesting function as a speaker hole (p. 394).

[29] Cfr. HAGEL 2010b.

[30] I am extremely grateful to Paul and Barbara Reichlin-Moser for sharing their as yet unpublished measurements and photographs, together with excellent drawings by Verena Pavoni, obtained during a research project funded by the Stavros Niarchos Foundation.

[31] BODLEY 1946, p. 225; pl. 3.2. Bodley's rejection of Howard's interpretation seems partly motivated by his adherence to the theories of Schlesinger 1939, now entirely discredited. His suggestion that the similar hole on the Pompeii *aulos* is also a rivet hole is of course irreconcilable with the fact that it sits on a rotary ring with knob traces and all; see above.

flect a historical evolution. As regards the first possibility, practically all of the instances definitely had no other purpose than opening a channel between the main bore and external air, and I cannot imagine any use of such an opening except in playing. Furthermore, all these known examples are placed so as to weaken or destroy the lowest oscillatory mode when opened, although not all are well suited to sustain the second mode, a twelfth higher. In other words, they would all serve to raise the pitch significantly, but very likely not in all cases by the same interval. On balance, at least their general function was very plausibly analogous, although perhaps with variation in detail. Such a general accord, however, lends more weight to the hypothesis of a historical evolution. Such an approach is of course encumbered by the fact that most of our items are at best very roughly datable. On the other hand, it would also be a token of poor methodology if we tried to trace a technical evolution from a such a small and diverse sample, even if the items were all dated exactly: the conditions of ancient music-making supported a cultural variety in which archaic types could co-exist with evolved forms, be it in less professional contexts or in a highly traditional environment such as rituals.[32] So all we can do is to find a plausible explanation that accounts for all the disparate facts.

The crucial question is: was there some rule of thumb which *aulos*-makers observed at a particular period, or in a particular industry, with regard to where a *sŷrinx* hole should be placed? As we have seen, according to modern physics the correct rule for speaker holes that are to support the second mode is to drill them at one third of the original quarter-wavelength. Unfortunately, since every note has a different wavelength, which is determined by various finger hole combinations, this entails, theoretically, a different speaker hole for every note. In practice, compromises can be found. Now it seems we are in the lucky position to determine at least one of the ancient rules with sufficient confidence: since the Berlin instrument represents an extant pair of pipes, both of which are equipped with such a hole, it can teach us how the positions of these holes were established. For it is clear that their placement was carefully chosen, since one pipe has it on its main part, but the other right through the wall of its bulb. The pipes are almost equally long, but on one the finger holes go higher up than on the other. Since this is also the pipe where the small hole is situated higher up, it follows that its placement depends on that of the highest finger holes. If the respective highest finger holes are taken into account, it appears that the small holes sit at approximately one third of their distance from the mouthpiece ends. This

[32] Cfr. *e.g.* Dion. Halic. *Antiqu. Rom.* 7, 72, 5.

impression is surprisingly well confirmed by the other remaining instruments with small holes below the bulb, those from Paestum and from Pompeii. On the former, because the mouthpiece end is unfortunately broken off, no distances can be measured; but the remains are compatible with the assumption that they had quite similar ratios, and in any case the higher pipe has its small hole located higher up. The sample of a comparatively simple wooden *aulos* and an early bone one is complemented by the elaborate Pompeii pipe made of ivory, silver and bronze. Although a priori one might not expect this kind of instrument to share such an important structural feature with the 'primitive' ones, its first-finger-hole to small-hole ratio is very close to the one of the Berlin *aulos*. In Figure 6, the relation is displayed graphically on the left: straight lines can be drawn through the centres of the respective holes, if the pipes are set up in parallel, mouthpiece ends aligned. However, these lines do not meet exactly at the level of the ends, but a little bit lower, as if for the decisive measurements a certain constant had been added, perhaps standing for the additional span of the reed.

At the right hand of Figure 6, the data are analysed by linear regression. The optimally fitting description would explain 99.4% of the data, assuming that the ancient manufacturers counterbalanced the reed effect by using a reference point at 22.6 mm beyond the mouthpiece end. But this mathematical idealisation does not help to explain anything, and the sample is anyway too small to raise such a claim. The assumption of a virtual reference point at this position would result in a ratio between the highest-finger-hole and the small-hole distances of about 2.38, a meaningless value: we can barely justify the assumption that the ancient makers drilled the *sŷrinx* at 42% the distance of the first finger hole. Actually the departure from the pipe end is statistically not significant: within a confidence of 90%, the reference point may as well have been identical with the end of the pipe. Such an assumption still explains 95.8% of the data, while having the huge advantage that the method to find the *sŷrinx* position becomes both simple and effective: simple, because it amounts to taking a third of the distance to the highest finger hole (calculated 34.5% ≈ ⅓ in very good approximation); effective, because this is just the acoustically optimal position, with the minor reservation that the reed cavity is not accounted for.

With so small a sample, we must of course count upon a meaningful interpretation of the data and cannot rely on the figures alone.[33] The

[33] From a purely statistical viewpoint, assuming normal distribution and the pipe end as the point of reference, the ratio is to be expected to lie between 23.9% and 45.0% with a confidence of 90%.

mean ratio, at any rate, is 1 : 3.036, almost exactly the required value. On Berlin 12462 it is a little smaller (1 : 3.31), probably because one did not want to drill through the thinnest part of the wall, where it tapers between the cylinder and the bulb (a point where many finds are broken) and manipulation would be encumbered;[34] the 'correct' place would have been 3 mm further down (cfr. Fig. 7). On the Pompeii pipe the ratio is a little larger (1 : 2.74). Here the 'ideal' position would have fallen within the lower part of the bulb section (which was similar on all four pipes), where no ring could be placed. The fact that the hole is actually located not at the centre of the ring but as close to the upper rim as possible, notwithstanding a possibly increased hazard of leakage, indicates that the makers felt that it 'ought to' have been positioned a bit higher on. On Berlin 12461, finally, the only example where no structural elements could actually interfere with its placement, the position agrees with the hypothetical ideal to the millimetre.[35]

In these pipes, therefore, the small holes are for all practical purposes optimally situated as speaker holes, so at last there can hardly be any doubt that this is exactly what their function was. An optimal placement, on the other hand, is likely to represent the endpoint of a technical evolution. Can we understand the other examples as possible precursors? I think so, and within a very plausible model at that. For, where is the *sŷrinx* effect likely to be detected at all? Holes usually do not open up by chance somewhere along a pipe, unless they were fissures that render the instrument entirely useless. Yet there is one particular point where slight leakage easily occurs; so easily in fact that probably every *aulos* player had plenty of experience with it and devoted much effort to preventing it (and so have I during some years of *aulos* practice): right at the mouthpiece end between the reed and the pipe. The reed was taken out after every performance and had to be re-inserted before the next; as it was moistened before a performance and continuously supplied with humid breath during it, the reed would expand, only to shrink again when drying up later; thus its airtight fit was often endangered. Very soft reeds may tolerate a very small leakage (although it always compromises the tone quality); but with a slightly harder reed or a larger leakage, it becomes impossible to elicit the basic mode, and the instrument starts to squeak instead.

[34] The wall thickness at the outlet of the hole at its actual position is c. 2.9 mm; at the 'ideal' position, it is only c. 2.3 mm.

[35] If we presume a similar ratio for the Paestum aulos, its bulb plus insert sections would have measured about 75 mm (assuming that their lengths were identical). Thus hardly more than 1 cm would be missing, implying an insert of the early type, roughly similar to that from Taranto displayed in Fig. 5, left.

As we have seen, such squeaks, *syrigmoí*, seem to have been sought for as special effects already in the archaic period, if our sources are to be trusted. In order to produce them in a controlled way, the most obvious thought would have been to induce voluntarily the otherwise unwanted leakage – by pulling out the reed a bit until the connection became less than tight. Of course this cannot be a very satisfactory procedure, since it allows no real control over the amount of leakage, while it poses the risk that the reed, if loosened too much, would come off entirely during performance. So it would have been desirable to define the exact size of the opening, while at the same time limiting the movement of the reed. So much could be achieved by a small hole such as we found on the Taranto fragment with the archaic insert form. It still worked by pulling the reed, but only by a small amount and without compromising its tight fit per se, while the maximum size of the opening was determined when making the instrument – and could be reduced with wax before a performance, if necessary.

Another option (though we don't know if it was something like a next step in a process of development) was to have the hole below the insert, thus breaking the immediate association between the squeaking effect and the reed. Even so, its placement as high up as possible appears to indicate the origin of the device in leaking inserts. This is what we observe on the other item from Taranto as well as on the Delos fragment, the Reading *aulos* and perhaps the bulb from the Agora. This type of hole was to be opened and closed outside; consequently the diameters could be larger, since the exact opening was anyway at the command of the musician. Once rotating sleeves had been invented, they could be applied to the *sŷrinx* too, as was probably the case on the Reading instrument. Finally it was realised that the technique to play in a high register had nothing to do with the mouthpiece section at all, and that speaker holes placed at other positions allowed better control of the achieved pitches. This led to the rule of thumb that we have detected on the Berlin and Pompeii pipes. That it was oriented towards the highest finger hole is not unreasonable: the lower the note, the easier it overblows even without any additional means. Thus the highest notes are the ones that require an optimal configuration, while the low ones will just as well do with a compromise. At the same time, this placement rule gives us as strong clue that the highest finger holes were indeed regularly taking part in *sŷrinx*-mode playing.

Notably, the Pompeii and Berlin *auloi* with their 'well-placed' speaker holes also share another characteristic: their highest finger holes play a note an octave and a fourth above their lowest possible pitch.[36]

[36] On the Berlin *aulos*, this is also true within pipe Inv. 12462 alone; in the case of the Pompeii pipe, if taken together with its obvious match, Inv. 76893.

Overblowing the lowest pitch therefore extends the scale to the next note, a tone higher.[37] But this presupposes that overblowing indeed produces the second mode and not anything even higher, and here it is certainly helpful to have the speaker hole placed in an appropriate position. On the other hand, if the Paestum *aulos* was already built according to the same rule, the *terminus ante quem* for its conception is much earlier than any evidence for *auloi* of the Berlin (and Louvre) type. In this case, the survival of the alternative technique of a *sŷrinx* close to the reed, side by side with the apparently more 'advanced' rule, may be more than a sign of technical conservatism: it might hint at different purposes, most likely the focus on different registers for overblowing.

Such considerations lead us back to a principal evaluation of the *sŷrinx*'s nature. When Aristoxenus uses two different verbs, αὐλεῖν and συρίττειν, for the modes of playing, the implication evidently is that these are nicely separated modes of musical expression, and the same idea emerges from Telephanes rejection of the device. Such a dichotomic concept is certainly far removed from that of a 'speaker hole' in the modern sense, designed to expand the scale seamlessly over more than one register, with the additional aim of covering up, as much as possible, the inevitable differences of timbre between the registers. With the *sŷrinx*, on the contrary, it was the contrast that counted. Accordingly, we have never found anything *sŷrinx*-like that could be operated during performance: at the very least, in the most advanced technique the record holds, the hand had to move upwards from its playing position in order to operate the switch; the more primitive types required more extensive handling, where the instrument needed to be taken out of the mouth.

Moreover, Aristoxenus' statement (quoted above) might imply that the kind of *surítttein* he had in mind was even higher than the second mode: in order to exceed the interval of three octaves using only the second mode, the highest finger hole of a particular instrument would have to play a pitch more than an octave and a fourth above its lowest note (cfr. Fig. 8). Of the published instruments, this is true only for another pipe from Pompeii, Inv. 76894, which however has no *sŷrinx*. The few instruments we know that have one would all need the third mode to reach such high notes; on an instrument designed similar to the Berlin *aulos*, the second mode would just extend to the third octave, not exceed it (if we leave aside minor variances such as discussed in the following paragraph). At any rate, the assumption of higher modes is in line with the seemingly early types of *sŷrinx* located very close to the mouthpiece,

[37] Cfr. note 38, below; also, HAGEL 2005.

which possibly impairs the oscillation of the second mode little less than the first.

Anyway the replication of the basic scale at a higher pitch would not have been possible on an instrument following the typical design of an *aulos*, in which the diameters of the holes do not, as a rule, increase towards the lower end. As a result, the intervals of higher registers are distorted – which perhaps added to the contrastive, monstrous effect of the *sŷrinx*. As far as we know, a solution to this distortion was not found in antiquity, and quite probably was never sought: on a cylindrical double pipe, the gap of a twelfth between the two lowest registers is way too large even to think of extensive scale expansion: this requires two hands playing on one pipe, sacrificing the production of harmonious intervals between the pipes, which is the essence of *aulos* music, for a greatly enlarged melodic range. Sure, the *mónaulos* existed, but it apparently never enjoyed as high a status as to earn significant attention from the virtuoso players whose needs drove the organological development.

At least with a 'correctly' placed *sŷrinx*, however, it became possible to extend the range of available notes upward a bit, using the highest finger holes plus the first overblown note, closing all the holes below those actually fingered. That this was a typical playing technique is proven by a musical papyrus, and by the particular design of the Berlin pair, whose pipe lengths are chosen in a way as to allow adding two consecutive notes above the highest finger hole by overblowing.[38]

A different path, it seems, was pursued by "Timotheus and his followers". If the interpretation I have suggested for the reference to goose-like sounds is not mistaken, they would have interspersed squeaky overblown notes within normal playing, thus breaching the traditional boundary between αὐλεῖν and συρίττειν and introducing the striking effects of the latter into a realm that had earlier been reserved for the former. Such a fusion of contrasts, of course, is exactly what Timotheus and his avant-garde colleagues were (and still are) renowned for. However, in order to use *syrigmoí* in that way, they would most likely have had to produce them without the help of the *sŷrinx* device: in order to evoke a resemblance to goose gaggle the pitch breaks must have been instantaneous, without any pause in between, which none of the extant mechanisms can do. We cannot rule out that other mechanisms existed, but I deem it much more likely that here the auletes would have used means of embouchure instead: releasing the lip pressure on the double reed may

[38] Pap. Michigan 1205 (DAGM Nr. 61), cfr. HAGEL 2010a, pp. 319-323; 341-343; HAGEL 2010b.

have such an effect, although the resulting pitch is not easily controlled.[39] But this was perhaps less of a problem, if it was the effect of a shrill squeak that was primarily sought.

A sound-related music-archaeological question is never satisfactorily answered unless experiment has proven the answer viable. Do the observed holes work as predicted? I have not built replicas of all the finds I have discussed here. As regards the fragmentary items, it is tedious to construct an instrument of which only a small part survives, in the awareness that the unknown parameters will cast doubt on the value of all experiments conducted on it. At least I can confirm from bitter experience that pipes squeak when they leak in the region of the reed insert. The Reading *aulos*, albeit a seemingly complete pipe, still holds many mysteries, and at any rate the metal encasing of its plausible *sŷrinx* is destroyed. The Paestum *aulos* is not yet published – but we may expect exciting results from Paul Reichlin's replica, which I have not yet had the chance to see in action. Which leaves us with the complete pairs from Berlin and Pompeii. A series of experiments on replicas of the Berlin pipes showed that their overblowing capabilities can be adjusted with little effort by partially pushing back a lump of wax from the small holes, whether on only one pipe or on both. In this way one shifts along a scale from no overblowing to overblowing only the low notes, creating an extension of the higher ones, and up to overblowing the notes from the higher finger holes also, just as predicted.[40] On the Pompeii pair, finally, only one of the pipes is equipped with a *sŷrinx*. I have confirmed its workability on a functional model of the instrument.[41]

Of our two extant *sŷrinx*-bearing pairs, then, only one has it on both pipes, and this is the instrument where it most clearly serves also to shift the normal playing range, not only to provide an alternate mode of sound production. On the highly expensive pipes from Pompeii, nothing would have prevented the addition of one on the other too, if this was in any way desirable. We must conclude that the musical context for which this instrument was built took it for granted that one pipe of a pair would remain in the basic mode even when the other changed to a higher register. This is all the more significant because here the highest finger hole of the pipe with *sŷrinx* lies merely a minor tenth above the lowest note, so that the scale cannot be seamlessly continued by overblowing (as is possible on

[39] This technique is used in the '*syrigmós*' played on a model of long Hellenistic pipes available at http://www.oeaw.ac.at/kal/agm/aulos/Syrigmos.mp3 (2011-04-26).

[40] For various configurations with sound examples see (and listen to) HAGEL 2010b.

[41] For sound examples hear HAGEL 2008b.

the Berlin *aulos*) without switching the melody between the pipes. Therefore the chances are good that the primary association of the *sŷrinx* of the Pompeii instrument is closer to the old paradigm of alternate playing modes, so different from each other that one almost talked of them as of two different instruments. This in turn might throw new light upon the passage from Aristoxenus discussed above, especially the phrase: … καὶ κατασπασθείσης γε τῆς σύριγγος ὁ τοῦ συρίττοντος ὀξύτατος πρὸς τὸν τοῦ αὐλοῦντος βαρύτατον μεῖζον ἂν ποιήσειε τοῦ ῥηθέντος διαστήματος. Usually the participles συρίττοντος and αὐλοῦντος are understood as referring to performers, and this is how I have rendered them in the translation given above. In this way, the sentence is perfectly understandable, but some uneasiness remains. On the one hand, the idea of performers seems introduced rather surprisingly after the preceding remarks, which talk about notes and instruments in an abstract manner. More importantly, the protasis given in the absolute genitive, "when/if the *sŷrinx* is pulled down" more naturally ought to govern the entire following sentence, while the usual interpretation demands that the reader decodes "in relation to the *aulos*-mode player" as leaving to be understood "if it is *not* pulled down". This is all the more awkward because the definite articles before the two participles would appear to imply a dichotomic situation which has been sufficiently defined in the foregoing – namely by the absolute genitive. Once again, I do not doubt that the text can be *read* as it is has usually been understood; but I doubt that it would be the natural way of *writing* it in order to express such a meaning.

On the level of the sentence, at least, I think there is a much more natural reading that avoids all these misgivings, ridding us of performers as well as restoring to the construction its natural flow of thought. The participles, I think, do not introduce people, but refer to *auloi*. *Auloi* in the genitive had appeared in the preceding phrase, split in the girls and the oversize type. In the case of φθόγγος, one of the governing nouns of this phrase is still to be understood in the following; there is no reason why this should not equally apply to αὐλῶν. Now again two types of *aulos* are compared, although with one big difference. Since the former comparison involved two classes of instruments, both of which come in pairs of pipes, there the plural was employed throughout. Now with the reference to pulling down "the *sŷrinx*" the focus narrows down to a particular instrument. This becomes clear from the following singular participles: if once more a general comparison between instruments playing in either way had been made, there would have been no reason to change from plural to singular. The domain of the protasis, finally, as well as the definite articles strongly suggest that the pulling down of the *sŷrinx* creates a situation

where a well-defined συρίττων stands against a no less well-defined αὐλῶν. This only makes sense if we take the singular to refer to the single pipes of one instrument (which as a pair was called either αὐλός in view of its forming a unity or αὐλοί with regard to its twin structure): «… and if the *sŷrinx* is pulled down, the highest note of the whistling [pipe] (*toû suríttontos*) would exceed the named interval in relation to the deepest note of the piping [pipe] (*toû auloûntos*)». Which is exactly the situation that the Pompeii *aulos* exemplifies, which has only one *sŷrinx*, and therefore not more than one pipe playing in *sŷrinx*-mode, which would then always contrast with the other that remained in *aulos*-mode.

As I have said, I think that this interpretation makes a much more natural reading at the level of the phrase. One might object to it that Aristoxenus' argument is about a meaningful definition of a largest consonant interval, facing the fact that in principle there is none. Even so, he proposes the double octave plus fifth, because no voice or single instrument exceeded this ambitus. The printed passage is part of a sequence of examples where three octaves or more may well be involved, but which however do not meet the criterion of «defining the compass by the range and limits of one particular instrument» (τὴν διάτασιν ὁρίζειν ἑνός τινος ὀργάνου τό<π>ῳ καὶ πέρασιν). The plausibility of the suggested interpretation will therefore depend on the question whether Aristoxenus would regard a pair of pipes, played simultaneously by one player, as not being one instrument in the sense his definition requires. Personally I think the problem is not insuperable, given Aristoxenus' focus on melody and the fact that the envisaged two pipes do not complement each other melodically. But here I happily defer judgement to the reader.

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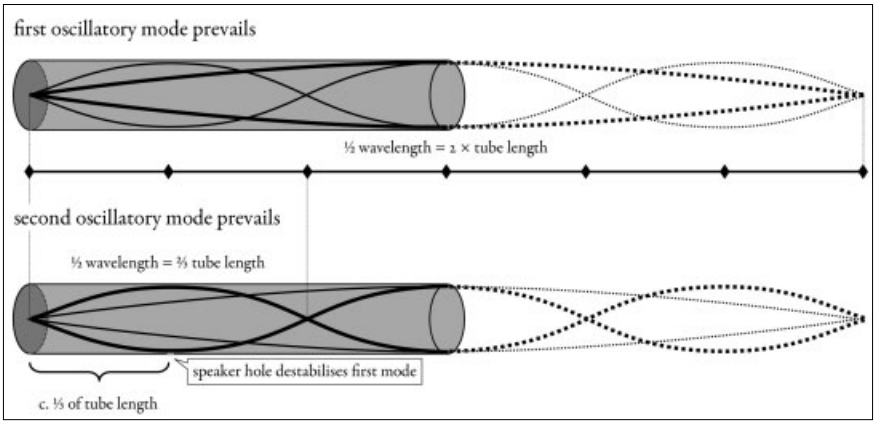

Fig. 1: Changing the dominant mode of oscillation by opening a speaker hole.

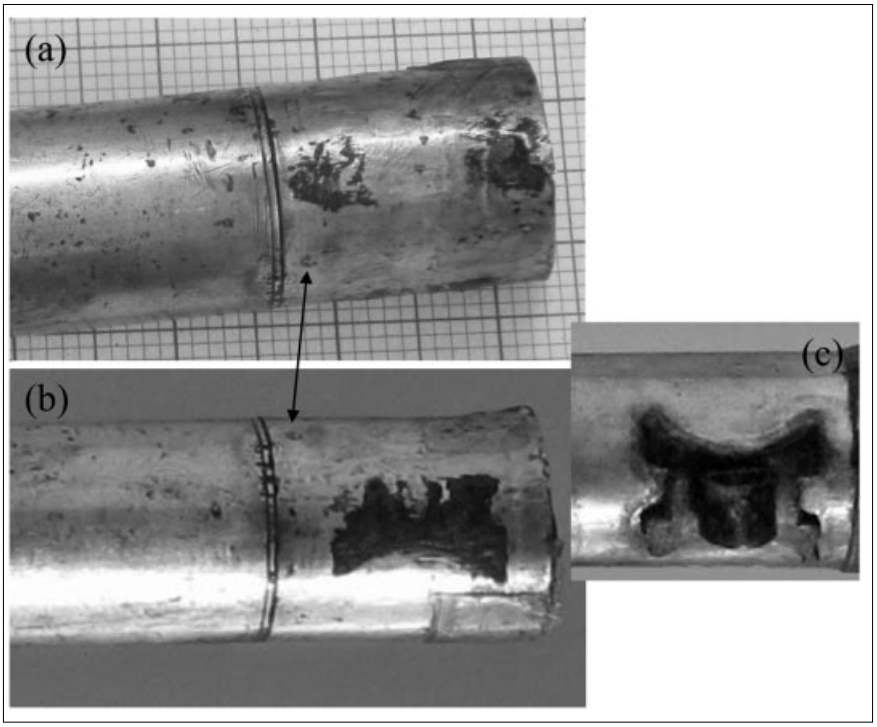

Fig. 2: The supposed *sŷrinx* of Naples National Museum, inv. 76892: (a) with hole facing the camera, (b) rotated backwards by 90°, with soldering traces facing the camera, (c) example of a similar knob still in place.
Photograph (a) by the author; (b) and (c) Naples National Museum; all courtesy of the Naples National Museum.

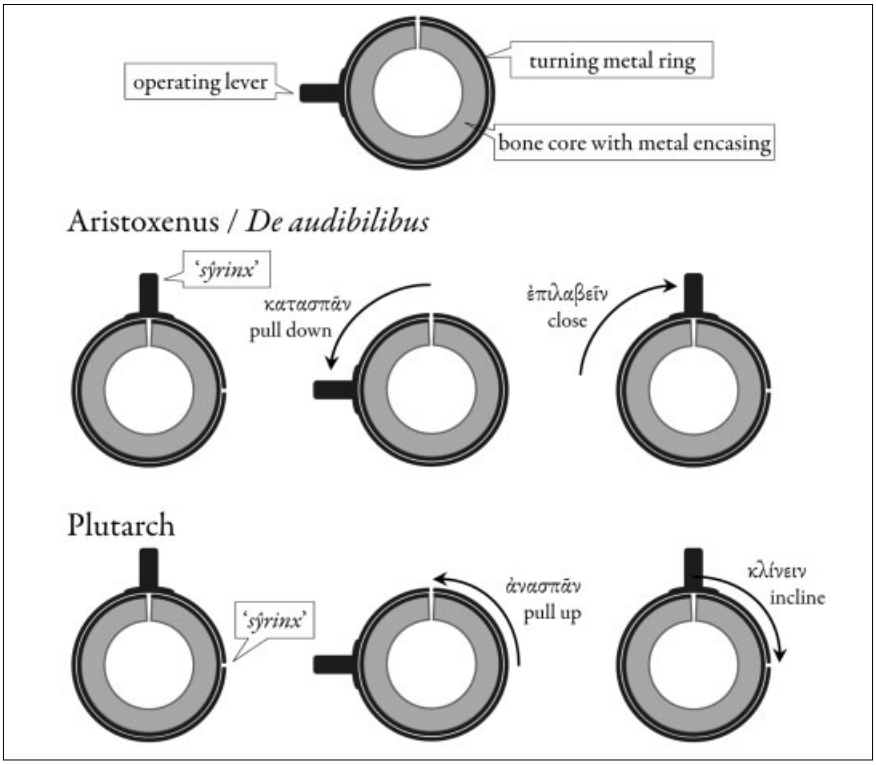

Fig. 3: The Pompeii-type *sŷrinx* and how to name its operation.

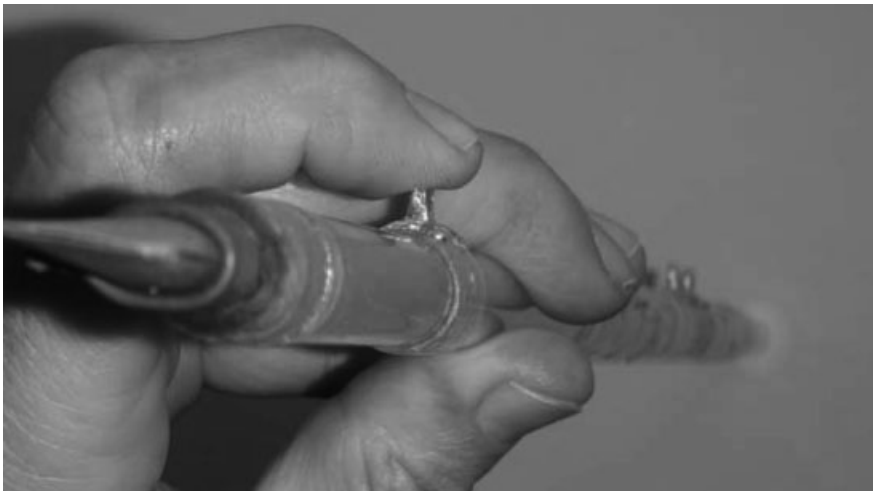

Fig. 4: Pulling down the *sŷrinx* on a functional model of Naples National Museum, inv. 76892.

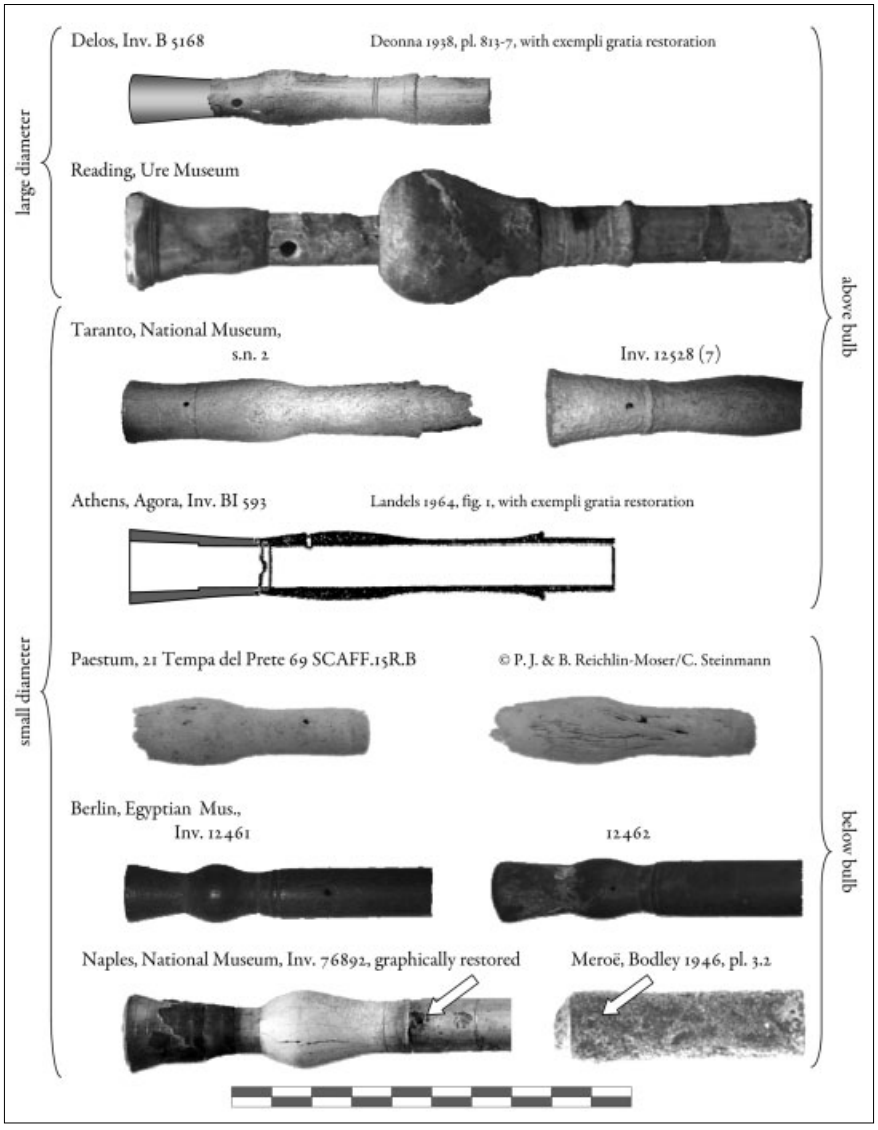

Fig. 5: Candidates for the *sŷrinx*, approximately to scale.

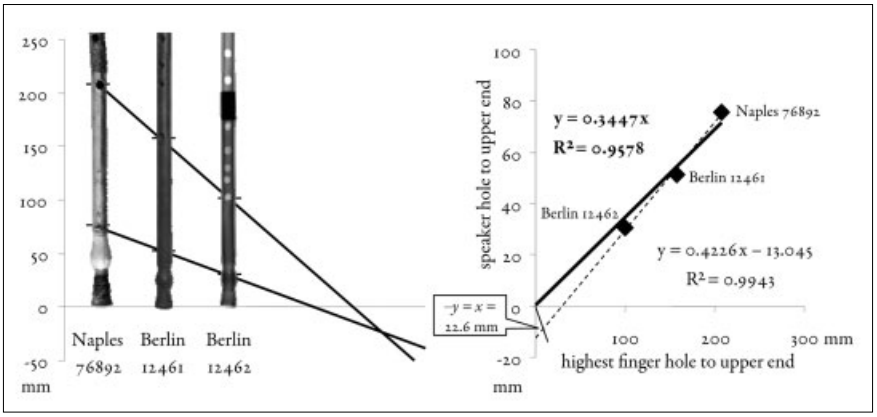

Fig. 6: *Sŷrinx* placement on the Berlin and Pompeii auloi.

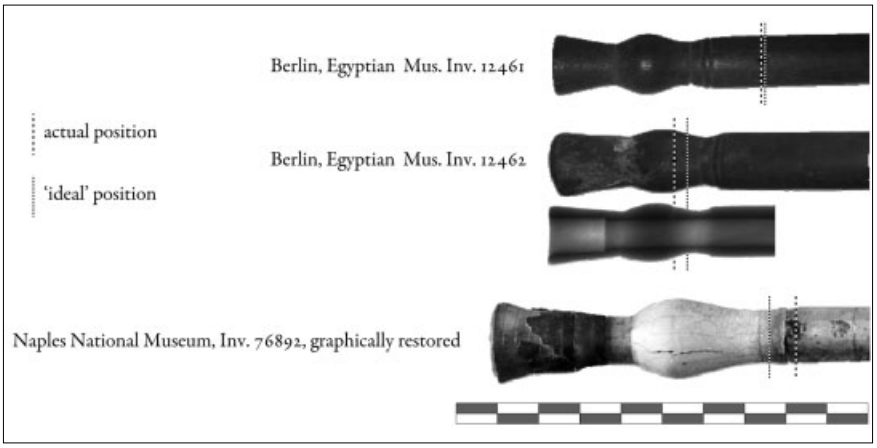

Fig. 7: Actual and hypothetically 'ideal' *sŷrinx* positions.

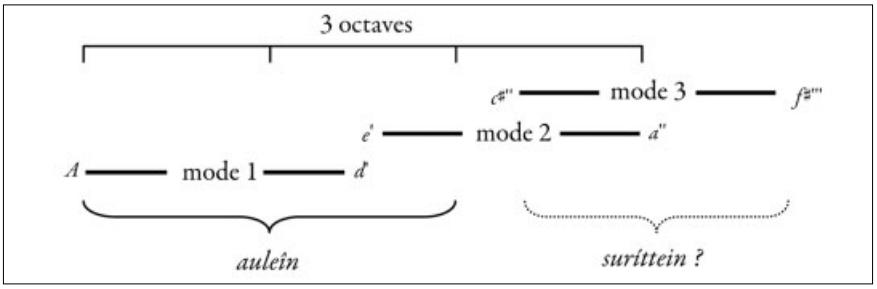

Fig. 8: Overblowing ranges of an *aulos* with the typical gamut of an eleventh (cf. HAGEL 2005, p. 87 f., with fig. 4).