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Creativity Through Analysis: New Approaches to the Serpent and Bass Horn

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The history of the serpent presents a developmental curve which changed dramatically around the turn of the nineteenth century. Following a fairly consistent if inconspicuous history over its first couple of centuries of existence,[1] the instrument suddenly found itself threatened by the tumult of the first industrial revolution. The serpent as it had hitherto existed—largely unchanged since the Renaissance—was beginning to be superseded by the bass horn, a family of instruments which itself was soon overshadowed by the rapid emergence of valved low-pitched labrosones.[2] As a result of these upheavals, the Romantic-era serpent and bass horn present a short-lived yet complex legacy of technological, creative, and acoustic development.

Composers from Beethoven and Mendelssohn through to Wagner and Verdi wrote for these instruments, yet many forms of bass horn seemingly vanished almost as soon as they were invented. Why did some of these instruments achieve far greater reach than others, and what sound worlds might have been forgotten by their demotion largely to the status of mere museum objects today? Meanwhile, contemporary performers on the rare forms of serpent and bass horn that are slowly being reintroduced into common performance practice arrive following training using modern labrosones whose organological developments and pedagogical traditions are dominated by sound ideals emerging from the second industrial revolution and subsequent world wars.[3] What might these instruments offer musicians engaged with the music of today aided by objective perspectives on these various layers of historical baggage?

Following an overview of their organological development between c. 1790–1860, I will present novel analytical methods which are employed in order to both differentiate timbre across a range of serpents and bass horns as well as compare the relative effectiveness of pitch control techniques and technologies. These methods are then contextualised and reflected upon using comparative audio-visual documentation of didactic, orchestral, and operatic repertoire, in addition to a newly-uncovered piece of chamber music. I will then discuss how these instruments can be utilised today, demonstrating resources which can stimulate creativity and experimentation while also reflecting organological characteristics, as well as presenting recordings of new complete pieces.

[1] A longitudinal survey recently surmised that "there is little written about or for the serpent in its first 200 years" (Beth Chouinard-Mitchell, *The Serpent Source Book* [Bombardon Books, 2023], 29). Less than one third of treatises and didactic texts analysed here predate the nineteenth century, only two of which date from earlier than 1770.

[2] A "labrosone" (Anthony Baines, *Brass instruments: Their History and Development* [London: Faber & Faber, 1976), 40] (or 'brass instrument') generates sound through vibration of the lips without any external membrane.

[3] Jack Adler-McKean, 'Serpents, Bombardons, and the "Wiener" Tuba: Richard Wagner and the Evolution of the Orchestral Contrabass Labrosone', *Historical Brass Society Journal* 34 (2022), 132–5.

The Romantic-era serpent and bass horn: a brief history

While the vernacular nature of the serpent has led to its early origins remaining fairly vague, evidence suggests that by the late seventeenth-century, the instrument was already in use in France, England, Germany, Italy, and likely further afield.[4] Such employments were largely constrained to sacred settings, with full emancipation from the church not taking place until the last quarter of the eighteenth-century when the instrument landed regular employment in military bands across Europe.[5] However, while the serpent found initial success here due to its ability to create bass resonances unmatched by contemporaneous aerophones, it was being pushed far outside of its comfort zone. The instrument's form factor is not well-suited to performance while marching or on horseback, and awareness had grown of its limited intonation control and dynamic inconsistencies resulting in notably "strong" and "weak" notes.[6] What emerged from these limitations was the development of bass horns, a term which covers a broad range of instruments that existed to varying degrees of scope over a highly fluid period of development. Nevertheless, all bass horns rely upon the same acoustic and technical principles as the serpent, yet feature a different ergonomic design (and therefore often a different bore profile), and/or utilise novel technical facilities. The voluminous number of designs of such instruments can be divided into two broad categories based upon their approximate developmental period.

Early bass horns

Initial attempts to make the bass horn more suitable for the marching band focused upon exploring alternatives to the 'S'-form of serpent had been largely standardised by the mid-seventeenth century (Illus. 1).[7] However, some manufacturers, particularly in England, maintained the 'S'-shape, but with tighter curves supported through metal bracing, creating instruments referred to as *military serpents* (Illus. 2),[8] while the *serpent Piffault* (Illus. 3) is an example of a figure-of-eight instrument wrap. Such instruments often featured closed-standing key-covered tone holes to aid production of certain non-diatonic pitches, additions which were also found on 'S'-shaped serpents of this period sometimes known as *serpents d'harmonie*.[9]

[4] For further details on the early origins of the serpent and associated performance practices, see Florence Gétreau (ed.), *Le serpent: itinéraires passés et présents* (Paris: CNRS Ed., 2013), notably François Auzeil, 'Les origines du serpent en France: nouvelles perspectives' (55–63), Bernard Dompiner, Isabelle Langlois and Bastien Mailhot, 'Serpentiste d'Église: une profession au XVIIIe siècle' (64–76), and Sabine Klaus, 'Serpent Precursors in Italy and elsewhere; the Serpent in the Low Countries and in Germany' (143–64).

[5] Jack Adler-McKean, 'The history and future of the tuba family,' *Timbre and Orchestration Resource* (2024): https://doi.org/10.5281/zenodo.11176627

[6] Chouinard-Mitchell, 40. For a further example of contemporaneous critique of the serpent's capabilities, see Gottfried Weber, 'Ueber Instrumentalbässe bey vollstimmigen Tonstücken.' *Allgemeine musikalische Zeitung* 18:41 (09.10.1816): col. 693–702.

[7] Marin Mersenne illustrates this form in 1637 (Marin Mersenne, *Harmonie Universelle contenant la théorie et la pratique de la musique*, vol. 4: *Traité des instruments* [Paris: Pierre Ballard, 1637], 279), although some other early serpents display a 'Z'-form, particularly those likely made in Italy (see, for example: Serpentone, Anon. (Italy), c. 1600. Museo Internazionale e Biblioteca della Musica, Bologna / 1829).

[8] Douglas Yeo, 'The Serpent in England: Evolution and Design' and 'The Serpent in England: Context, Decline, and Revival,' in *Le serpent: itinéraires passés et présents*, 203–212, 253–265.

[9] M. G. Hermenge, *Méthode Elémentaire de Serpent- Serpent Ordinaire et à Clé* (Paris: Richault, 1816), 5.

Illustration 1: Serpent. Baudouin (Paris), ca. 1820. Edinburgh / 3606

Illustration 2: Military serpent. Metzler & Son (London), ca. 1825. Edinburgh / 3372

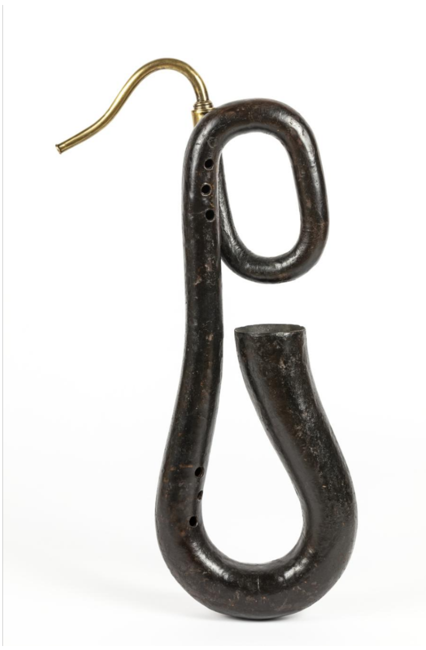

Illustration 3: Serpent Piffault. Piffault (Paris), early 19th century. Edinburgh / 6418

Such key-covered tone holes were omnipresent when serpents began to be built in an upright form, the earliest of which *serpents droit* is credited to J. J. Regibo in 1789 (Illus. 4), an Italian musician living in Lille.[10] These 'upright serpents' were constructed in a similar manner to a bassoon, often with separate wing and bell sections connected via an internal 'U'-bend foot section, and have therefore commonly been referred to as some variation or translation of *serpent basson* or *Russische Fagott* ('Russian' likely being a misreading of 'Prussian' where these instruments achieved wide popularity). Some of these instruments incorporated metallic additions, such as a flared bell (sometimes zoomorphic) (Illus. 5) or a tuning slide (Illus. 6), while some of Jean Baptiste Coeffet's *ophimonocleides* (Illus. 7) feature a movable cylindrical section in the middle of the body to allow for use in a variety of tonal centres alongside one open-standing key-covered tone hole of a proportionally wide-enough diameter to have significant harmonic effect (as will be discussed below). As opposed to the more common finger-covered tone holes and closed-standing key-covered tone holes which raise pitch when engaged (that is, when a tone hole is opened), open-standing keys are used to lower the pitch, and were used here and on many later bass horns to allow for alternative production of tones which would otherwise require the majority of tone holes to be open and therefore have a notably different dynamic response to those which require all or most holes to be closed.

Some manufacturers experimented with intonation solutions that involved the boring of tone holes into opposing bores (or even both ascending and descending bores simultaneously) within the foot section in order to lengthen the harmonic distance between neighbouring finger positions,[11] or adding 'double' key mechanisms, leading some 'upright serpents' to incorporate up to seven key-covered tone holes alongside their six finger-covered tone holes.[12] The English bass horn (EBH) (Illus. 8) is a 'V'-form instrument designed by London-based French serpentist Louis Alexandre Frichot in 1799 which commonly features an additional key-covered hole (also found on some upright serpents) between the finger-covered hole closest to the bell and the C-sharp key. Empirical practice has determined that this key is utilised for production of C2, with the standard combination for this pitch (all six finger-covered holes closed) resulting in a B1.

Chromatic bass horns

The instruments listed above all utilise the same fundamental technical configuration: the same six finger-covered tone holes of the 'S'-shaped serpent plus a number of closed-standing (and occasionally open-standing) key-covered holes to aid in production of some pitches. Later models moved away from this form, utilising ever more keys to cover tone holes significantly larger than those which could be covered by fingers until each chromatic pitch was assigned its own hole combination. Nevertheless, some models still maintained the the original 'S' (or 90-degree-rotated 'W') shape, English manufacturers as well as Ludwig Embach of Amsterdam

[10] Herbert Heyde, 'The Bass Horn and Upright Serpent in Germany. Part 1: The Continental Bass Horn,' *Historical Brass Society Journal* 27 (2015), 21–39, here 21. None of Regibo's own instrument designs are known to have survived.

[11] Craig Kridel, 'Bass Horn', in Laurence Libin (ed.), *The Grove Dictionary of Musical Instruments* (second edition) (Oxford: Oxford University Press, 2014), 252-4, here 252.

[12] See, for example, bass horns from Hanken of Rotterdam with seven keys, and from Wiesner of Dresden with six keys.

Illustration 4: Serpent droit. Anon (Netherlands), ca. 1825. Amsterdam / NG-NM-10385-144

Illustration 5: Basson russe (Dubois & Couturier), ca. 1840. Edinburgh / 6500

Illustration 6: Serpent Forveille. Forveille (Paris), early 19th century. Edinburgh / 6091

Illustration 7: Ophimonocleide. Coeffet fils (Gisors), ca. 1835. Edinburgh / 3598

Illustration 8: English bass horn. Griesling und Schlott (Berlin), early 19th century. Private

Illustration 9: Keyed serpent. Roe (Liverpool), early 19th century. Edinburgh / 6056

Illustration 10: Violoncell-Serpent. Embach (Amserdam), 1830–35. Leipzig / 1586

Illustration 11: Chromatisches Basshorn. Anon. (Germany), ca. 1830. Edinburgh / 6445

Illustration 12: Bass-Euphonium. Haseneier (Koblenz), 1850–60. Leipzig / 1601

Illustration 13: Kontrahorn. Lamperhoff (Essen), ca. 1845. Cologne / 294

Illustration 14: Serpent coeffet. Jean Baptiste Coeffet, 1825–40 (Chaumont-en-Vexin). Leipzig / 1599

replacing the finger-covered holes with open-standing keys alongside closed-standing keys for each non-diatonic pitch (Illus. 9 and 10). In Germany, Johann Heinrich Gottlieb Streitwolf's 'U'-formed *chromatisches Basshorn* (CBH) (Illus. 11) maintained two finger-covered holes,[13] while later manufacturers replaced these with additional closed-standing keys, such as Heinrich Johann Haseneier's *Bass-Euphonium* and J. & A. Lamperhoff's *Kontrahorn* (Illus. 12 and 13). Some inventors focussed on lowering the instrument's range; the *Kontrahorn* has a fundamental pitch of G1, while Coeffet's eponymous *serpent coeffet* employs six closed-standing keys (alongside three finger-covered holes) to produce a fundamental pitch of E-flat 1 (Illus. 14).[14] Alongside multiple key configurations, these instruments tended to feature more complex bore profiles than their predecessors; a contemporaneous advertisement for Streitwolf's CBH states that "the external form is largely similar to the common English bass horn ... only the internal design and position of holes and keys are significantly different."[15]

[13] I have examined several other instruments in this exact form without Streitwolf's signature (see examples listed in Table 1) possibly built as prototypes or by apprentices of Streitwolf, all with slightly varying tone hole positions and diameters, but the same overall technical configuration and material construction.

[14] By modern pitch standards, bass horns are commonly found with nominal fundamental pitches (with all finger-covered holes closed and no keys engaged) varying from B-flat 1 to D2 (most commonly C2), although defining how these relate to historical pitch standards requires further longitudinal study.

[15] Johann Heinroth, 'Beschreibung und Empfehlung eines von G. Streitwolf in Göttingen verfertigten chromatischen Basshorns,' *Allgemeine musikalische Zeitung* 41 (11.10.1820): col. 688–689, here col. 688.

Illustration 15: Ophicleide. Labbaye (Paris), 1837. Private

Alongside these largely wooden instruments is the ophicleide (Illus. 15), an all metal 'U'-shaped instrument invented by Jean Hilaire Asté in Paris, originally with eight closed-standing keys and one open-standing key, with later models adding one or two extra closed-standing keys. These instruments are commonly treated as being organologically distinct from other bass horns,[16] yet from the perspective of performance practice rather than geo-historical evolution, their form, construction manner, and technological facilities are analogous to many of those instruments listed above.[17] Other fully-keyed all-metal instruments of this size have elsewhere been described as *bombardons*, and while there are notable variations in bore size and bell flare,[18] differentiations have concluded that "there is a clear overlapping" with ophicleides.[19] The ophicleide did, however, achieve significantly wider prevalence outside of the military band than all other bass horns, and its continued popularity throughout the nineteenth-

[16]See, for example, Clifford Bevan, *The Tuba Family* (Winchester: Piccolo, 2000), 63–180.

[17]For example, regarding 'S'-shaped serpents constructed out of metal, see Sabine K. Klaus, 'Serpente aus Metall,' in *Vom Serpent zur Tuba: Entwicklung und Einsatz der tiefen Polsterzungeninstrumente mit Grifflöchern und Ventilen*, ed. Christian Philipsen (Augsburg: Wißner, 2019), 19–38.

[18]Herbert Heyde, 'The Bass Horn and Upright Serpent in Germany. Part 3: Bombardon and Ophicleide' *Historic Brass Society Journal* 29 (2017): 13–45, here 14–19. Regarding the name *bombardon*, see Jack Adler-McKean, 'Serpents, Bombardons, and the "Wiener" Tuba.'

[19]Ignace de Keyser, 'The keyed ophicleide as a paradigm in the development of the new wind instruments in the 1830s and 1840s,' in *Vom Serpent zur Tuba*, 69–88, here 78.

century led to frequent demands from orchestral and operatic composers.[20]

Serpent and bass horn differentiation

The invention and implementation of the valve in the early nineteenth century had a dramatic effect on both the variety and the technical capabilities of labrosones being built, resulting in a fundamental shift in the skills required from performers, and the aesthetic parameters available to composers.[21] When assessing the capabilities and characteristics of instruments which preceded this movement, especially in light of the propagation of homogenized modern labrosones (as will be discussed later), a multitude of methodological perspectives can be applied. For example, metallic aerophones survive for longer periods in playable condition (that is, without any physical damage) than those made largely out of wood, particularly bass-register labrosones which require primarily high-flow, low-pressure sound propagation and therefore involve a considerable volume of warm, humid air being expelled into upper portions of the instrument as a by-product of lip-reed activation.[22] As primarily military service instruments that were discarded when deemed no longer fit for purpose, the survivorship of extant bass horns could suggest that these models were, in fact, less favoured for employment when they were new. Meanwhile, as the last half-century has seen a gradual revival of some of these instruments in performance practice, repertoire is being uncovered which requires fresh perspectives upon their relative employment. Quantitative data analysis can add an empirical perspective to these discussions, helping to inform both historical arguments as well as how these instruments can be utilised today.

Timbral analysis

The existence of low-pitched aerophones is well documented by the early seventeenth-century, notably including forms of instruments which today are described as (contra)bassoons, and (contra)bass trombones.[23] However, these instruments could not create strong low spectral content due to their relatively narrow bore, whereas the serpent's wide minimum bore and conical profile enables production of lower-frequency harmonics at significantly greater amplitudes.[24] The dynamic and timbral range of an acoustic instrument is generally described using descriptive metaphors such as *piano* and *forte* dynamics or 'dark' and 'bright' colours. Dynamics, meanwhile, through their association with the concept of volume can also be approached analytically through assessment of the amplitude of the relevant sinusoidal wave,

[20] Adler-McKean 'The history and future of the tuba family.'

[21] For further historical contexts, see Elizabeth Bradley Strauchen-Scherer, 'Technology and Timbre: Features of the Changing Instrumental Soundscape of the Long Nineteenth Century (1789–1914)' in *The Oxford Handbook of Timbre*, ed. Emily I. Dolan and Alexander Rehding, (Oxford University Press, 2018): 404–32.

[22] Alan Watson, 'Breathing,' in Trevor Herbert, Arnold Myers, and John Wallace (eds.), *The Cambridge Encyclopedia of Brass Instruments* (Cambridge: Cambridge University Press, 2019), 81–4.

[23] See, for example, the *Quart-Posaunen*, *Doppel-Fagott*, and *Bas-Pommer* illustrated in Michael Praetorius, *Syntagma Musicum* Vol. 2: *De Organographia* (Wolfenbüttel, 1620): 6–9. Regarding the use of 'contra' as a descriptor for some bass-register labrosones, see Adler-McKean, 'The history and future of the tuba family.'

[24] The contrasting characteristics these instruments led some Romantic composers to integrate the serpent within the bassoon family (at times assigning them the same part), which has proven to be an acoustically successfully combination (Murray Campbell, 'Serpent and Contrabassoon Acoustics,' *International Tuba Euphonium Association Journal* 31[4] [2002], 54–5; see also Adler-McKean 'The history and future of the tuba family').

whereas the more complex nature of timbre has been commonly left to the realm of value judgments, such as the concept of production of a "good tone."[25] While a multitude of factors contribute to the perceived timbre of a labrosone, including "the pitch of the note played, the embouchure of the player, and the acoustics of the room in which the sound is heard," the timbral potential of an instrument itself can be assessed through a novel calculation, the Spectral Enrichment Factor (E).[26] This approximation uses bore measurements across the tube length of the instrument in order to produce a figure where 1 represents as minimally spectrally enriched (or as 'dark') and 10 as maximally spectrally enriched (or as 'bright') as possible. In doing so, it calculates the contribution of non-linear sound propagation—the shock wave created by the steepening of the front of a sinusoidal wave, commonly known in labrosone practice as 'brassiness'—to the 'brightening' of timbre.[27]

Measurements taken to date suggest that E can help differentiate between various instrument types and also within instrument models or generations of the same family. For example, taking three instrument families with the same nominal pitch, French horns are around E=6–7, baritone Saxhorns are around E=4–5, and euphoniums are around E=3–4,[28] while regarding low-pitched labrosones, modern tubas are around E=2.3–2.6, while nineteenth-century 'Berliner' tubas are around E=3.2–3.6.[29] E calculations necessitate a degree of approximation, especially with regard to historical wooden instruments where internal bore diameters are often difficult to measure accurately, also given possible alterations that have been undertaken since the instruments were first constructed. Nevertheless, a large enough data set (Table 1) can illustrate general trends in spectral profiles across various families of instruments (Table 2). This data suggests that the early 'upright serpent' form of bass horn produces a significantly brighter timbre than 'S'-shaped serpents, a distinction analogous, for example, to that between a sackbut and a modern trombone. This discrepancy is mitigated somewhat by EBHs, while Streitwolf's CBH models are closer to earlier upright serpents. Later CBH models are considerably closer in timbral profile to serpents, while ophicleides are similar if slightly brighter on average.

[25] Arnold Myers, 'Timbre', in Trevor Herbert, Arnold Myers, and John Wallace (eds.), *The Cambridge Encyclopedia of Brass Instruments*, 401–02 (Cambridge: Cambridge University Press, 2019).

[26] Murray Campbell, Joël Gilbert, and Arnold Myers, *Sounding Brass: Brasswind Instruments and How They Work* (Cham: Springer, 2025), 50–54. For further examples of methodological approaches to assessment of timbre, see Gunter Ziegenhals, *Subjektive und objektive Beurteilung von Musikinstrumenten: eine Untersuchung anhand von Fallstudien* (Dresden: TUDpress, 2010), 148–53.

[27] Campbell, Gilbert, and Myers, *Sounding Brass*, 47–50. Another notable factor that can have an impact on labrosone timbre is the choice of mouthpiece; serpents are commonly associated with mouthpieces featuring a right-angle between the cup and shank, while bass horn mouthpieces tend towards a more rounded backbore, reducing the white noise component to the timbre. The "Rogers Mouthpiece" was "designed [to] produce the characteristic sound of the serpent" using a modern euphonium or baritone horn (https://www.berliozhistoricalbrass.org/rogers.htm), although empirical testing is needed in order to examine the efficacy of this design, as well as study more generally the potential role of mouthpiece geometry in definition and manipulation of labrosone timbre.

[28] Campbell, Gilbert, and Myers, *Sounding Brass*, 53.

[29] Jack Adler-McKean, 'The solo tuba: reevaluating instruments, timbres and performance practices,' *Performance Research 30.1 On Music* (2025) (DOI: 10.1080/13528165.2024.2537555).

Table 1: Spectral Enrichment Factors for serpents and bass horns

Instrument type	Museum Location / No.	Construction date	Manufacturer, location	Interfaces	SEF (*E*)
Serpent	Edinburgh / 3606 (AM)	c. 1820(?)	Taylor, Glasgow	6FH, 4CS	2.18
Serpent	Edinburgh / 3303 (AM)	1768	Anon., France	6FH	2.39
Serpent	Edinburgh / 1156 (AM)	c. 1825	Haye, London	6FH	2.41
Serpent**	Edinburgh / 3606 (AM)	c. 1800	Baudouin, Paris	6FH	2.48
'Late' CBH**	Leipzig / 1601 (HH)	c. 1855	Haseneier, Koblenz	2OS, 9CS	2.23
'Late' CBH	Leipzig / 1586 (HH)	c. 1830–35	Embach, Amsterdam	7OS, 6CS	2.29
'Late' CBH	Leipzig / 1599 (HH)	c. 1830–35	Coeffet, Gisors	3FH, 6CS	2.42
'Late' CBH	Cologne / 294	c. 1845	Lamperhoff, Essen	1OS, 10CS	2.80
Ophicleide	Munich / 46304	c. 1845	Barth, Munich	1OS, 10CS	2.44
Ophicleide	Private	c. 1835?	Labbaye, Paris	1OS, 8CS	2.45 [2.68]*
Ophicleide**	Göttingen / 514	c. 1840	Gautrot, Paris	1OS, 9CS	2.53
Ophicleide	Markneukirchen / 811 (AM)	c. 1856	Courtois, Paris	1OS, 10CS	2.54
EBH	Markneukirchen / 87 (AM)	c. 1830	Anon., Saxony?	6FH, 4CS	2.79 [2.89]*
EBH	Amsterdam / BK-NM-5495	c. 1830	Anon., Netherlands?	6FH, 3CS	2.87
EBH**	Private	c. 1830	Griesling und Schlott, Berlin	6FH, 4CS	2.81
EBH	Edinburgh / 883 (AM)	c. 1830	Sandbach, London	6FH, 4CS	2.96
'Streitwolf' CBH	Markneukirchen / 102 (AM)	c. 1820(?)	Anon., Germany?	2FH, 2OS, 8CS	3.00 [3.26]*
'Streitwolf' CBH	Edinburgh / 1761 (AM)	c. 1820	Anon., Germany?	2FH, 2OS, 8CS	3.08
'Streitwolf' CBH**	Munich / 10223	c. 1820	Streitwolf, Göttingen	2FH, 2OS, 8CS	3.17
'Streitwolf' CBH	Brussels / 1240	c. 1820(?)	Anon., Germany?	2FH, 2OS, 8CS	3.25
Upright serpent	Private (AM)	c. 1840	Dubois & Couturier, Lyon	6FH, 3CS	3.16
Upright serpent	Amsterdam / NM-10385-144	c. 1820(?)	Anon., Netherlands?	6FH, 2CS	3.20
Upright serpent**	Private	c. 1820	Doke, Linz	6FH, 4CS	3.24
Upright serpent	Private	c. 1810	Cuvillier, St. Omer	6FH, 3CS	3.34

*: Instrument length likely to have been modified since construction: calculation in bracket using measured length, calculation outside of bracket using likely original length.
**: Instrument represented in Charts 1–6. EBH: English bass horn. CBH: Chromatic bass horn. AM: Data collected by Arnold Myers. HH: Data collected by Herbert Heyde. FH: Finger-covered tone hole. CS: Closed-standing key-covered tone hole. OS: Open-standing key-covered tone hole. Edinburgh: University of Edinburgh Collection of Musical Instruments. Leipzig: Musikinstrumentenmuseum der Universität Leipzig. Cologne: Kölnisches Stadtmuseum. Munich: Deutsches Museum München. Markneukirchen: Musikinstrumentenmuseum Markneukirchen. Amsterdam: Rijksmuseum. Brussels: Musée des instruments de musique Bruxelles.

Table 2: Average Spectral Enrichment Factors for serpent bass horn archetypes

Instrument type	**SEF (*E*)**
Serpent	2.37
'Late' chromatic bass horn (CBH)	2.44
Ophicleide	2.49
English bass horn (EBH)	2.86
'Streitwolf' chromatic bass horn (CBH)	3.13
Upright serpent	3.24

This data suggests that earlier bass horns were less successful at replicating the timbre of the serpent than those which followed later. Such findings, at a subjective level, can be supported by audio-visual documentation produced using comparable instruments. Music from Berlioz (Recording 1) appears to demonstrate the similarity in timbral profile between the 'S'-shaped serpent and the *serpent Piffault*, while in the Mendelssohn Bartholdy excerpt (Recording 2), it is perhaps possible to distinguish the notably darker timbre of the ophicleide from both the EBH that the part was originally written for, and the CBH.[30] Bellini's music (Recording 3), meanwhile, may illustrate how similar the various forms of upright serpent-style bass horn sound to each other (despite different bell styles, construction materials, and pitch standards) in comparison with the 'Verdi' cimbasso commonly used for performances of this music today.[31] The *serpent Forveille* features a wider bore profile than most upright serpents, resulting in a value of E=2.59 which suggests a notably close timbral profile to an 'S'-shaped serpent. This is arguably reflected M. G. Hermenge's étude for the instrument (Recording 4), with the *serpent Piffault* producing a timbre close to that of the *serpent Forveille* itself (albeit still slightly 'darker'), while the upright serpent and CBH-style instruments are notably 'brighter'.

Tone hole acoustics

Mechanical pitch control on serpents and bass horns is provided by tone holes, the effectiveness of which can be quantified using the sound power transmission coefficient (T_m). This calculation uses measurements of a tone hole's diameter, chimney height (the distance it branches out from the main tube), and corresponding bore diameter in order to calculate the fraction of total sound energy that can be effected at various frequencies.[32] Here, 0 represents a fully-effective tone hole with no sound energy getting past, while 1 indicates that all sound energy bypasses the tone hole and it has no resultant effect on pitch control. A tone hole effectively functions as a high-pass filter with a cut-off frequency (defined as the frequency for which T_m=0.5) broadly dependent upon the ratio between the diameter of the tone hole and the diameter of the corresponding bore.[33] The highest cut-off frequencies (and thus most effective tone holes) are achieved when these diameters are broadly comparable, making

[30] For hyperlinks to these recordings, see page 38.
[31] Italian bass horns are often referred to using the abbreviated, translated portmanteau *cimbasso* (that is, *c.[orno] in basso*), while the 'Verdi' cimbasso is a form of valved (contra)bass trombone (Renato Meucci, 'Il cimbasso e gli strumenti affini nell'Ottocento italiano,' *Studi verdiani* 5 [1988–89], 109–162).
[32] Murray Campbell, Joël Gilbert, and Arnold Myers, *The Science of Brass Instruments* (Cham: Springer, 2021), 161.
[33] Ibid.

finger-covered tone-holes effective for instruments with narrow and/or cylindrical bores such as cornettos or recorders, yet the serpent requires a wide, conical bore in order to produce its characteristic strong lower-frequency harmonic support.

Charts 1–6 illustrate the effectiveness of the tone hole furthest from and nearest to the bell (in red and blue, respectively) using examples from each type of instrument listed in Table 1. This data suggests that an EBH and upright serpent allow for greater sound transmission at low frequencies than the serpent despite also utilising finger-covered and/or broadly finger-sized key-covered tone holes. CBHs and ophicleides display a lower threshold of power transmission, meaning that lower frequency sounds can be controlled more easily as they are now largely manipulated using key-covered holes which are proportionally closer in size to the relative bore of the instrument, although still with a relative weakness of the holes furthest from the bell (and thus with the widest relative bore). These charts also illustrate how overall cut-off frequency generally increases as the relative size of the tone hole increases, but the effect of a tone hole is also modified by the relative conacity of the tube, as well as the position and number of similarly-sized tone-holes that are simultaneously opened, an important factor here given the physiologically compromised positioning of many serpent and bass horn tone holes.

The pragmatic reason behind a serpent's 'S'-shape is that it forms an attempt to space the tone holes proportionally across the instrument's tube length of approximately 2.2m while still being in reach of both hands simultaneously. This results in two groups of three holes spaced c. 330mm apart, while the spaces between the holes within each group of three are limited by the spacing between each fingertip of c. 40mm. Tone holes 1–3 of the serpent in Chart 1 result in a combined cut-off frequency of 416Hz (c. G-sharp 4), making them effective at controlling pitches across the majority of the range of the instrument. However, the gap between holes 3 and 4 (that is, between the two hands) results in a drop of the combined cut-off frequency to 193Hz (c. G3), only recovering to 226Hz (c. A3) when the neighbouring holes 5 and 6 are also opened. This situation, which is also reflected in upright serpents and EBHs, results in holes 4–6 having significantly less acoustic effect (particularly in the middle and upper registers) than holes 1–3. In comparison, the cumulative cut-off frequencies of the ophicleide illustrated in Chart 6 never drop below 370Hz (c. F-sharp 4), making all of the tone holes acoustically effective across the majority of the instrument's range. This relative acoustic efficacy is also reflected when comparing ratios of tone-hole to bore diameters across the length of the cone, varying by factors of 0.13, 0.12, and 0.11 with the Streitwolf CBH, later CBH and ophicleide as opposed to 0.29, 0.30, and 0.50 with the serpent, upright serpent, and EBH, respectively.

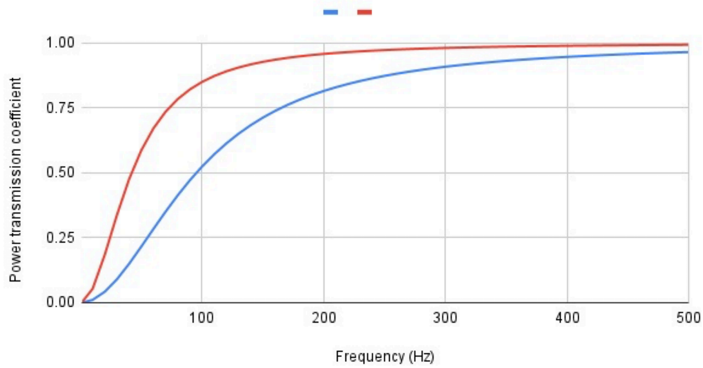

Chart 1: Power transmission coefficient for a serpent

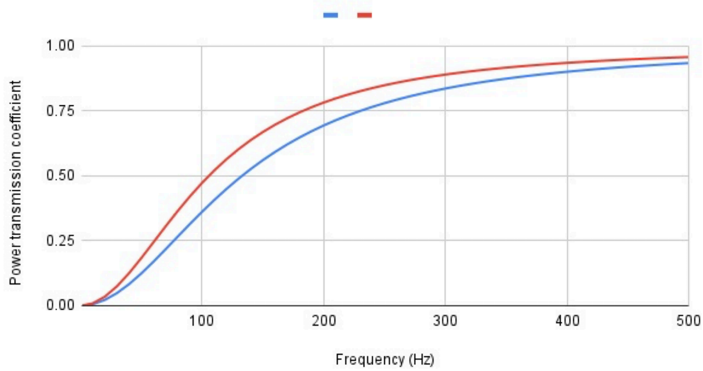

Chart 2: Power transmission coefficient for an upright serpent

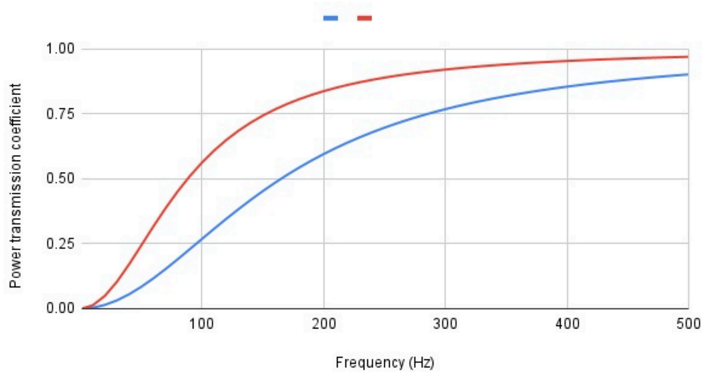

Chart 3: Power transmission coefficient for a English bass horn

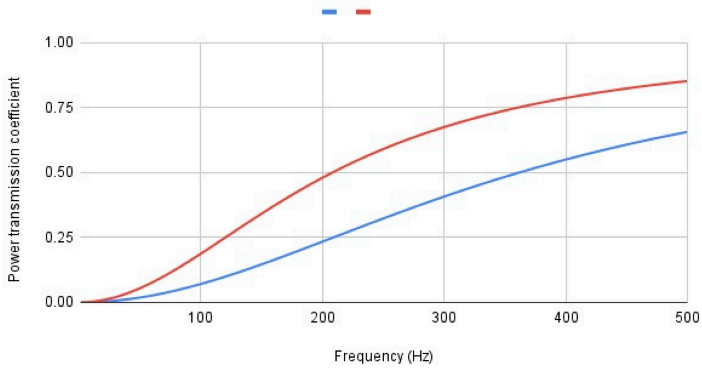

Chart 4: Power transmission coefficient for a 'Streitwolf' chromatic bass horn

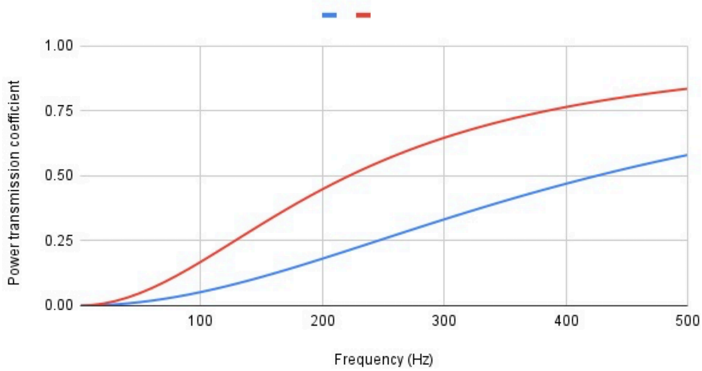

Chart 5: Power transmission coefficient for a 'late' chromatic bass horn

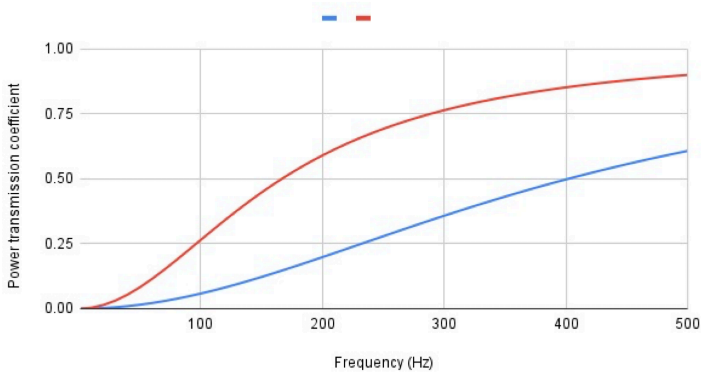

Chart 6: Power transmission coefficient for a ophicleide

Instrumental employment today

This empirical data can help inform the choice of instrument for performance of music written for serpent and bass horn today. As discussed earlier, the reach and availability of various serpents and bass horns varied widely in the early nineteenth century, while today, 'S'-shaped serpents and ophicleides can be found with relative ease, yet other bass horns such as EBHs and CBHs are encountered far more rarely. The findings above go some way to explain these situations; for example, Streitwolf's invention likely failed to find common usage as Heinroth advertised "supporting the wind section in our orchestras" in part due to the fact that it produced a notably brighter sound than the serpent that it was intending to replace, with little notable timbral differentiation from existing upright serpents.[34] Other questions, however, are more difficult to answer using this data alone. Why, for example, are later CBHs found in very small numbers given that they come close to replicating the timbre of the serpent while also being able to mechanically differentiate pitches across the instruments' range? Insight here is provided through awareness of broader perspectives; for example, Embach's *Violoncell-Serpent* features a complex array of eight open-standing and five closed-standing keys, thereby providing a significant technical challenge to any potential learner as well as a high risk of mechanical failure. Haseneier's *Bass-Euphonium*, meanwhile, at over 1.2m tall with an all-wood construction, requires significant physical force to manipulate, while keys of a diameter up to 57mm will result in loud, largely unmitigable mechanical operation noises. Moreover, these instruments' emergence coincided with the bass tuba being granted its patent on 12 September 1835 in Berlin, an instrument that would rapidly revolutionise low-pitched labrosone performance practice in Germany, the homeland of the CBH, and also further afield.[35] In comparison, ophicleides present a relatively light, all-metal construction, and had already established significant performance practice traditions in France in both military band and concert hall settings by the mid-1830s where they were not fully superseded by the tuba for almost half a century.[36]

Louis Massonneau's *Quartetto per il Corno di Basso Inglese*

A widespread lack of organological consistency of low-pitched labrosones has resulted in composers having little agency over which specific instrument might be used in performance of their music from at least the early nineteenth century up until the present day.[37] Therefore, when a work is encountered which specifies such an instrument by name, informed decisions need to be made to overcome logistical constraints in technical skill or instrument availability. A case study is provided by a recently uncovered work, a *Quartetto per il Corno di Basso Inglese* for viola, violoncello, double bass, and EBH from Louis Massonneau, signed from Ludwigslust in 1817 where Massonneau led the orchestra from 1812–37.[38] Sebastian Seipolts-

[34] Heinroth 'Beschreibung und Empfehlung,' col. 688.

[35] Adler-McKean, 'The solo tuba.'

[36] Joseph Brousse, 'Le Tuba,' in *Encyclopédie De La Musique*, Vol. 8, ed. Albert Lavignac and Lionel de la Laurencie (Paris: Libraire Delgrave, 1925), 1674–80.

[37] Adler-McKean 'The history and future of the tuba family.'

[38] Louis Massonneau, *Quartetto per il Corno di Basso Inglese* (Ludwigslust: manuscript, 1817), Landesbibliothek Mecklenburg-Vorpommern: Mus. 3608/1.

dorff was a violinist in the orchestra at this time,[39] and he was also the founding serpentist of the *Hofharmonisten* wind ensemble.[40] As a student of Massonneau, this bass horn part was therefore likely written for Seipoltsdorff (perhaps as an unusual take on the string quartet format), especially given that other references to an EBH from Ludwigslust such as a wind ensemble arrangement from *Hofharmonisten* clarinetist Cornelius Hammerl end in 1817 shortly before Seipoltsdorff's death in the following year.[41] His successor in the *Hofharmonisten* was August Rodatz, also a violinist in the orchestra and student of Massonneau, who, in 1826, likely played the EBH part in the premiere of Felix Mendelssohn Bartholdy's *Nocturno*.[42]

Accessing an EBH in playable condition today (including modern replicas) is extremely difficult, meaning that an informed choice is likely needed in order to realise this music in concert. The timbral analyses above would suggest that the sound of an EBH would be most closely reproduced by an ophicleide, yet the data comparing technical facilities would suggest that a serpent would be a more accurate replacement. Recording 5 presents selections from each movement of this piece recorded using an EBH, while Recording 6 compares excerpts from this recording with the same passages recorded using a serpent and an ophicleide. Reflection upon these recordings from both a performer's and a listener's perspective suggest that this data is accurate; the serpent is more technically suited to this work—in other words, the technical limitations of the EBH also broadly apply to the serpent—while the EBH's timbral palate is more accurately reproduced by the ophicleide. Following this test cast, larger-scale studies involving live performances in a variety of circumstances will be required in order to produce a comprehensive assessment of the extent to which the choice of low-pitched labrosone can affect chamber and ensemble music of this era and be informed by empirical data. For example, the most frequently encountered work specifying this instrument is Mendelssohn Bartholdy's Overture to *Ein Sommernachtstraum*, Op. 21 (see also Recording 2), and performances today often feature an ophicleide.[43] These acoustic analyses suggest that the ophicleide is an effective timbral substitution, albeit while presenting notably different technical challenges to the performer, a hypothesis worthy of comparison with other possible instruments for this role both historical and modern.

New music for serpent and bass horn

The data analyses above suggest that the serpent and bass horn present a diverse range of sonic resources, much of which has since been subsumed by an ever-more homogenised range of brass instruments, popular models today often being set apart by fractions of millimetres in

[39] 'Personale der herzogl. Mecklenburg-Schwerinischen Hofcapelle zu Ludwigslust,' *Allgemeine musikalische Zeitung* 14:30 (22.07.1812), col. 500–502, here 500.

[40] Landesarchiv Mecklenburg-Vorpommern, *2.26-2 Großherzogliches Hofmarschallamt / Personalangelegenheiten / Hofpersonal / Einzelne Personen*, 3008.

[41] Personal communication from Stefan Fischer via email, 28.01.2025.

[42] Achim Hofer, *»es möchten manche Leute Vergnügen daran haben« Felix Mendelssohn Bartholdys »Ouvertüre für Harmoniemusik« op. 24* (Würzburg: Königshausen und Neumann, 2018), 20–34.

[43] Despite Mendelssohn Bartholdy specifying EBH in the manuscript here and again in his later incidental music (*Musik zu Ein Sommernachtstraum*, Op. 61), the first published editions of these works changed the instrument name to ophicleide.

bore diameter if at all.[44] An opportunity is therefore presented to musicians working within contemporary idioms wishing to take advantage of this diversity of timbre and technique. My preparation of a guidebook for the contemporary tuba was heavily influenced by my (at this stage, only qualitative) assessments of historical tuba family instruments, forcing me to rethink the very nature of how such instruments can be approached by both performers and composers.[45] Recent didactic and analytical texts on labrosone performance practice rely heavily upon haptic feedback;[46] while an important component of performance analysis, especially for instruments where sound resonance is propagated directly by the human body without an external membrane,[47] this focus on sensory feedback can result in value judgements that expose inherent aesthetic biases. My exploration of the timbres and technologies presented by serpents and bass horns led me to actively avoid value judgments or 'otherings' in my writing, for example, regarding common false dichotomies of sounds as "normal" or "special", techniques as "standard" or "extended", and repertoire as "traditional" or "contemporary."[48] By approaching the resonant structure of a labrosone as a whole, as an air-containing body which can be controlled and manipulated in various ways, one can allow for nuance and experimentation with sound generation that can shape how the instrument can be most effectively utilised.

To extend this approach towards historical instruments themselves, I have created analogous playing guides for the serpent and bass horn with the aim once more of stimulating channels of communication between performers and composers.[49] Here, organological and acoustic information can once more be augmented by audio-visual documentation in order to illustrate the accompanying charts and understand the requisite techniques from a creative perspective. These resources are especially important here given the lack of contemporary encounters with these instruments outside of isolated circles, and the extent to which they diverge from those in common practice. For example, in comparison with modern labrosones, the weaker overall harmonic structure of the serpent resulting from a continuous conical bore with little bell flare and inconsistent tone-hole positions leads to a significantly stronger responsibility for the embouchure in controlling both pitch and timbre.[50] Audio-visual material can be used to highlight the limitations, creative possibilities, and alternative solutions

[44] For example, when comparing minimum bore diameters (the primary contributory factor to spectral enrichment) of the common F tuba, identical figures are presented by all ten of the readily available models sold under the brand Miraphone, six of the eight models on offer from B&S, and six of the nine models on offer from Melton, with an average variance from the median minimum bore of 1.04%. (https://www.thomann.de/de/tuben.html). In comparison, the minimum bore diameters of five Streitwolf-style CBHs deviate from the median by an average of 6.21%, while those of six later CBH models deviate by 9.04%.

[45] Jack Adler-McKean, *The Playing Techniques of the Tuba / Die Spieltechnik der Tuba* (Kassel: Bärenreiter, 2020), 18–31.

[46] Adler-McKean 'The history and future of the tuba family.'

[47] Physiological awareness in labrosone performance practice has undergone significant research in recent decades, notably by Dr. Peter Iltis (https://www.mpinat.mpg.de/626938/brass-playing).

[48] Malte Burba and Paul Hübner, *Modern Times for Brass: Experimental Playing Techniques for Brass lnstruments* (Wiesbaden: Breitkopf & Härtel, 2019), 19, 55; Trevor Herbert, 'Extended techniques' in Trevor Herbert, Arnold Myers, and John Wallace (Eds.), *The Cambridge Encyclopedia of Brass Instruments* (Cambridge University Press, 2019) 165; Mike Svoboda and Michael Roth, *The Techniques of Trombone Playing / Die Spieltechnik der Posaune* (Kassel: Bärenreiter, 2017), 65–68.

[49] These are available at https://www.jackadlermckean.eu/playing-techniques-historical-instruments.

[50] Adler-McKean, *The Playing Techniques of the Tuba*, 81–4.

to pitch control presented by this situation. For example, on one hand, Recording 7 demonstrates the first seven partials of the serpent's harmonic series, highlighting the increasingly weak role of the lower three holes as the pitch increases (as discussed earlier), while Recording 8 uses the first four harmonic series of the ophicleide to demonstrate how lip bending plays a significant role in the lower register and how this decreases and tone holes become more significant in controlling pitch between the first and sixth partials. On the other hand, Recording 9 presents some of the possible complex sounds on the serpent when extreme lip bending results in multiphonics (this recording also demonstrating the relatively fragile and unstable nature of this technique), while Recording 10 demonstrates some alternative options for pitch content generation on the ophicleide through creation of pitched white noise resonances alongside various percussive sounds.

Studio recordings of new works for serpent can illustrate the techniques listed in future editions of the playing guides to the instruments. Orlando Bass's *La carne terra* (Recording 11) provides contrasting options for employment of multiphonics as well as possibilities for timbral diversity through formant manipulation. In *UŠḪUM.GAL* (Recording 12), Henrik Denerin explores combinations of the serpent and the voice in close intervals alongside use of the 'pedal' register and options for quarter-tone articulation. Athena Corcoran-Tadd's *Chrysopeleia* (Recording 13) employs percussive sounds and a mute to explore further options for timbral manipulation, also juxtaposing the serpent's lip-reed and white-noise sonic resources against vocalisations and whistle tones. Meanwhile, Jesse Ronneau's *yet none have returned* (Recording 14) exploits the instruments propensity towards creation of microtonal scales, glissandi, and white noise resonances in combination with live electronics. Resources such as these can never replace the working relationship between a performer and a composer, but they have nevertheless been shown to "establish a fundamental level of knowledge and mutual understanding, which can then be used as a base for further creative developmental practices."[51]

Conclusions

When exploring what these instruments might offer composers and performers today, the potential for idiosyncrasies traditionally seen as detrimental to be exploited as creative impulses means that a degree of organological separation from historical contexts is required in order to provide opportunities for external analysis that can build upon a performer's haptic feedback. In order to promote a multifaceted approach to historical music for labrosones that can move beyond the tacit norms of modern instrumental design, practice, and their resulting sonic palates, quantitative data can play a role alongside historical contexts and recording-based auto-ethnographic reflection when considering the interplay between materiality, timbre, and performance practices. The next step in this explorative process is to utilise CT scanning, 3D printing, metamaterials and other technologies in order to explore how organological and timbral diversity can be promoted amongst the modern hegemonic instrumental families of Western classical music. By exploring these methods as symbiotic rather than opposing views on both organology and performance, a wide diversity of sonic explorations can be fostered.

[51] Jack Adler-McKean, *Tubas, Tubists, and Composers: a mixed-methodological approach to performer and composer-instrument relationships,* PhD Thesis (Royal Northern College of Music in collaboration with Manchester Metropolitan University, 2022), 73–8.

Taken together, these perspectives aim to demonstrate a sustainable practice method which promotes an experimental approach to historicism.

Recordings

- Recording 1: Hector Berlioz, *Symphonie Fantastique*, 1830 (serpent Piffault, serpent, euphonium)
- Recording 2: Felix Mendelssohn Bartholdy, Overture to *Ein Sommernachtstraum*, 1827 (chromatic bass horn, English bass horn, ophicleide, euphonium)
- Recording 3: Vincenzo Bellini, *Norma*, 1831 (basson russe, serpent Forveille, 'early' cimbasso, 'Verdi' cimbasso)
- Recording 4: M. G. Hermenge, *Rondo* from *Méthode Elémentaire pour le Serpent-Forveille*, 1835 (serpent Piffault, basson russe, serpent Forveille, chromatic bass horn)
- Recording 5: Louis Massonneau, Quartetto per il Corno di Basso Inglese (excerpts), with Jessica Thomas (viola), Karolin Spegg (violoncello), and Johannes Ragg (double bass)
- Recording 6: As recording 5 comparing use of an English bass horn, ophicleide, and serpent
- Recording 7: Harmonic series (partials 1–7) on a serpent
- Recording 8: Lip-bending on the first four harmonics (partials 1–6) on an ophicleide
- Recording 9: Multiphonics on a serpent
- Recording 10: Slap tongues, key clicks, and white-noise sounds on an ophicleide
- Recording 11: Orlando Bass, *La carne terra*, 2024–25 (solo serpent)
- Recording 12: Henrik Denerin, *UŠḪUM.GAL*, 2024–25 (solo serpent)
- Recording 13: Athena Corcoran-Tadd, *Chrysopeleia*, 2024–25 (solo serpent)
- Recording 14: Jesse Ronneau, *yet none have returned*, 2024–25 (serpent and live electronics)