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AN EXPLORATION INTO THE USES OF EXTENDED TECHNIQUES IN WORKS FOR THE SAXOPHONE, AND HOW THEIR APPLICATION MAY BE INFORMED BY A CONTEXTUAL UNDERSTANDING OF THE WORKS THEMSELVES

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Abstract

This thesis investigates how the specific manipulation of a range of extended techniques for the saxophone can help the performer to highlight key aspects of the music. These techniques can be performed with varying levels of nuance through which the implicit thematic relationships within a composition can be emphasised. The performer's interpretation is therefore aided by the controlled manipulation of extended techniques, with the intention of using these techniques to serve the overall analysis of the composition.

A brief summary of the acoustical phenomena which produces the saxophone's range of extended techniques is included, leading to discussion of the necessary physical manipulations of the oral cavity, alterations of fingerings systems, and other such physiological issues.

The differences from performer to performer of the resulting sounds of the saxophone's extended techniques are considered through reference to recorded material. A discussion is presented regarding individual performers' attitudes to these techniques including the preparation of extended techniques, the importance of equipment, and the performer's opinion of the composer's utilisation of extended techniques within a composition.

The final section outlines the preparation of seven compositions which use extended techniques: four of which are taken from the saxophone's standard repertoire and three of which were written in collaboration with the author. It is not the author's intention to present a global methodology by which extended techniques can be sounded in performance; rather it is the author's intention to highlight how the manipulation of these techniques, through an understanding of the acoustical and physiological nature of their production, can be performed with a nuanced production technique that can enhance the interpretation of the work as a whole.

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Introduction

Interpretation

Edward T. Cone writes about the audience's perception of art which occupies a single temporal space, as opposed to those art forms which can be re-experienced such as painting, sculpture, or the written word. The performance arts which are experienced in a single moment in time can only present one interpretation at a time, and therefore are 'not an approximation of some ideal' (Cone, 1968, p.34). This presents an interpreter with a question 'which of the relationships implicit in this piece are to be emphasized, to be made explicit?' (Cone, 1968, p.34). The same question can be posed of compositions which include an array of extended techniques as a performer relies upon the composer's notation of extended techniques in order to produce a sound that is appropriate for that point in the composition. The emphasis of certain musical aspects (pitch, rhythm, timbre) within the production of an extended technique is based upon the performer's understanding of the role of that technique within the composition as a whole. The relationship between performance and analysis is highlighted by authors such as John Rink, Edward T. Cone and Joel Lester; and a definition between 'academic analysis' and 'performance analysis' is generally agreed upon. John Rink writes that 'it must be stressed that “performer's analysis” primarily as an interpretation is being formulated and subsequently re-evaluated' (John Rink, 2002, p.39). This confirms Cone's statement that choices are made about the composition during the process of rehearsal, which then inform an interpretation. This presents the listener with an interpretation whose 'findings are assimilated into the generalised body of knowledge that lies behind but does not dominate any given performance act' (John Rink, 2002, pp.39-40), again promoting the choices the performer makes when preparing a performance. Joel Lester refers to the score as a 'map' or 'recipe' for something which exists 'beyond its score' (Lester, 1995, p.199), and this is particularly relevant when discussing extended techniques where a complex sound, with multiple opportunity for nuance, is communicated to the performer through the visual medium of notation. Lester goes on to state the following:

> 'each nuance limits the piece by excluding other options for that element. In this sense, a performance is necessarily only a single option for that piece, delineating some aspects while excluding others'
>
> (Lester, 1995, p.199)

The performer makes their choices based upon the context of the work as a whole to decide which relationships need to be expressed, and therefore how extended techniques are to be sounded using a nuanced performance technique to achieve their interpretational goals.

Christian Lauba, in his piece *Neuf Etudes* (1996), manages to successfully integrate multiphonic intervals into the musical language of the composition, resulting in a work which uses voice leading in both the top and middle parts of the multiphonics to create the illusion of a melodic line; especially in the movement entitled *Savane*. In the performance directions for the composition, the composer states that 'The fingerings of the multiphonic sounds are only recommendations... The player must respect the written intervals and find fingerings which are the best adapted to his instrument' (Lauba, 1996). This statement is problematic, because if a performer's instrument will not produce the correct intervals in a multiphonic, changing the fingering cannot hope to fix this problem as other multiphonics will be sounded that may fix one interval whilst altering another. The approach Lauba takes to his composition is therefore problematic, because stipulating specific fingering choices in relation to multiphonic interval production can result in different intervals sounding. This is due to the saxophonist's own physiology, understanding of tongue positions, and equipment choice which are all variables in the resulting sound that will be produced when performing extended techniques. It is generally acknowledged that this level of unreliability is characteristic of multiphonics, and in contrast to Lauba's statement Chris Redgate's article entitled *Performing Sequenza VII* (2007) quotes Paul Roberts explaining Berio's understanding of this fact:

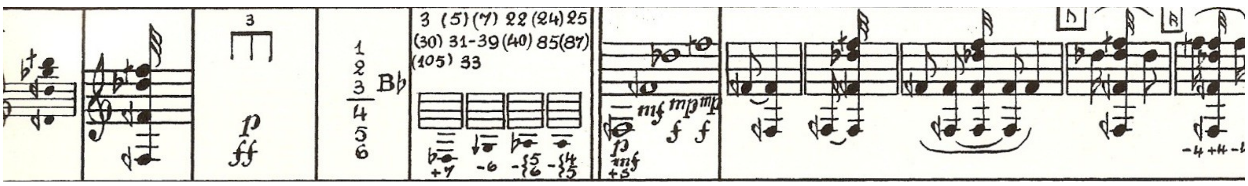
> Luciano Berio was a practical musician and realised that this notation of the multiphonics could not be 100% precise. In a performance of Sequenza VII the player (oboist, or saxophonist) must produce a convincing effect with the multiphonics. The quarter-tone indications should be understood as margins of error, since it is taken for granted that a perfect intonation is almost impossible.
>
> (Roberts in Redgate, 2007)

Other variables which affect the sound of extended techniques include instrument bore shape, mouthpiece choice and reed strength. Mouthpiece choice can alter the sound and timbre of certain techniques as 'closed' tipped mouthpieces (typically used for playing the classical repertoire) allow less reed vibration than 'open' tipped mouthpieces which allow more partials to sound in the overall timbre and are therefore often used for jazz playing where a brighter tone is often preferred. When performing techniques which involve the harmonic series such as spectral sweeps, harmonics and multiphonics, the saxophonist's knowledge of specific tongue positions and vocal tract tuning is essential not only to produce an accurate and nuanced sound but often to achieve the technique at all. Likewise an understanding of the mechanical workings of the saxophone in relation to forked fingerings and saxophone specific mechanisms (like the articulated G# mechanism) is advantageous in devising alternative fingerings for microtones. This allows the performer the opportunity to choose from a number of fingerings depending on the microtonal sound that is required. These issues are all resolved through the analysis of the surrounding compositional material, and by considering the choices of fingerings or sound production methods available based upon the physical manipulation needed to produce the desired sound.

There are problems with compositions for the saxophone which draw upon extended techniques as the pedagogy for this style of music is not as developed as it is with other woodwind instruments. Claude Delangle and Jean Michat state that 'coming from a state of "no fixed repertory", the saxophonist can often end up trying everything, as much a polymath as his instrument is a polymorph' (Delangle & Michat, 1998 p.161). Delangle and Michat observe that the saxophonist must 'sympathise with the dilemma of the contemporary composer – how to build on quasi-virgin territory?' (Delangle & Michat, 1998 p.162). Methods of notation for extended techniques such as key clicks, multiphonics, quartertones, spectral sweeps, singing whilst playing, harmonics and slap tongue can be problematic as they introduce a level of ambiguity surrounding the appropriate sound that is to be made. It would be a mistake for a performer to rely solely on established fingering diagrams without considering the sound that will result from this method of production, as these fingerings could produce a number of different outcomes depending on the variables of instrument choice, mouthpiece setup and individual physiology, as mentioned previously.

The very fact that there are so many possibilities to manipulate a single multiphonic fingering and split it into its subsequent partials, as demonstrated in Kientzy's *Les Sons Multiples Aux Saxophones* (2003, figure 1 column 7), indicates the transient nature of the technique, and the level of nuance needed in the production of the sound required (track 1 of the accompanying CD). The interpretative responsibility of the performer is therefore

Fig.1 Kientzy multiphonic number 1 for alto as taken from *Les Sons Multiples Aux Saxophones* (2003)



paramount as each partial of a multiphonic with a strong oscillation, for example, can be emphasised or even sounded individually depending on the performer's tongue position. Column 7 of figure 1 depicts the sounds that can be produced from a single fingering using the tongue to suppress certain partials and to move between them creating the effect of 'fading in'. The fact that multiphonics behave in this way offers the performer a choice as to which pitch or interval within this multiphonic can be emphasised, depending on its role in the context of the work as a whole. For instance if the lower partial is a pitch which the performer deems to be important to the work, but in practice it is the softest due to the nature of the multiphonic, the performer can manipulate the other partials to bring this pitch to the foreground; thereby realising the performer's interpretation of the piece as they understand it.

Likewise when choosing microtonal fingering combinations the performer can elect to employ different fingering systems found within pedagogical texts such as Weiss & Netti's

The Techniques of Saxophone Playing (2010) and Jean-Marie Londeix's *Hello! Mr. Sax* (1989) in order to achieve the exact microtonal interval desired. As the use of microtones in each specific work differs, then the emphasis of each microtonal interval can also be treated differently; a performer can augment or diminish the interval in order to highlight the distance between two pitches, or can choose microtones close to a regularly tempered pitch to highlight the proximity of these two sounds.

These decisions can be used by the performer to an artistic advantage based upon an understanding of the composition, as Eric Clarke describes in his article *Expression in Performance*:

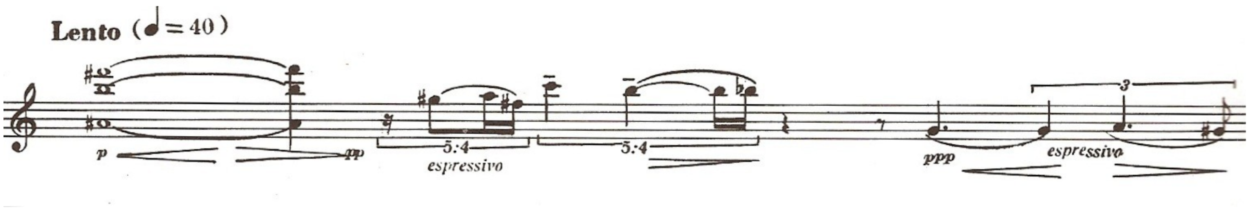
> Although the structure of a composition determines… [the] field within which an interpreter can operate, the performer has the capacity within that field to manipulate the acoustical and temporal realisation
>
> (Clarke, 1995 p.51)

It is by considering the exact degree of this manipulation, as well as the understanding of the physiology of the larynx and tongue positions required, with reference to the musical context of the technique within the composition that performers are able to present a controlled and accurate interpretation. Through manipulation of physiology and an understanding of the acoustical aspects of each extended technique performers can manipulate the acoustical aspects of the music within the boundaries set by the composer. By highlighting pitch relationships; microtonal qualities; and exploiting the behaviour of the reed, the performer can present a nuanced and accurately produced interpretation of the extended technique the work calls for.

Edison Denisov Sonata for Alto Saxophone and Piano (1973): An Early Use of Multiphonics

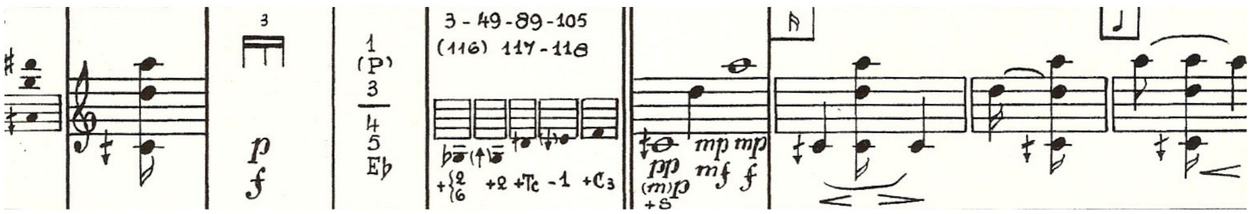
This manipulation of extended techniques can be demonstrated by looking at the first use of saxophone multiphonics in Denisov's Sonata for alto saxophone (1973), where the first multiphonic of movement II is pitched to the notes A4 a quartertone sharp, B5 and F#6 (figure 2). The note F#6 is also the last note in the saxophone part of the previous movement and so it is important to make this note prominent whilst playing the multiphonic.

Fig.2 Edison Denisov Sonata for Alto Saxophone and Piano (1973) mvmt 2 line 1



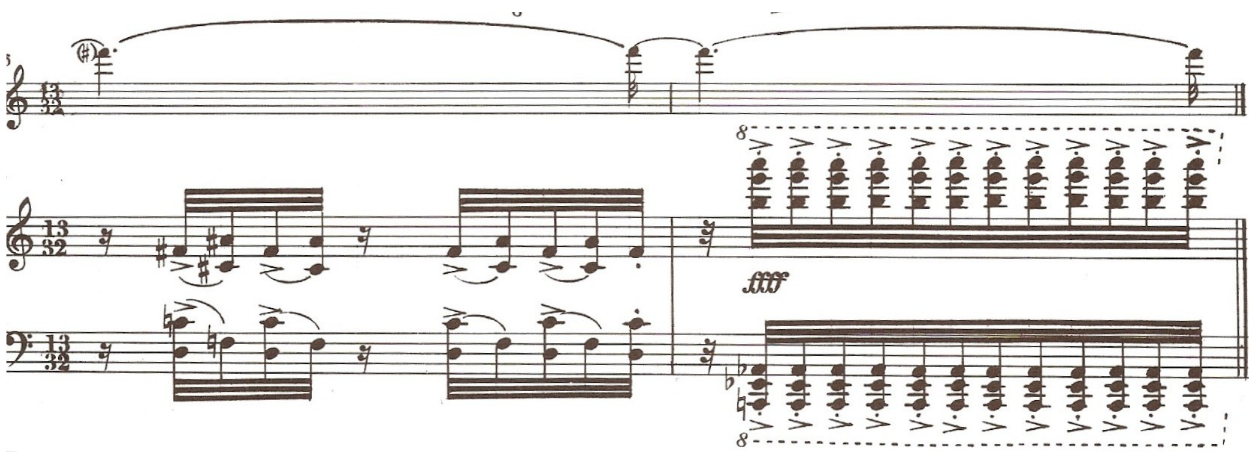
This pitch is emphasised using the tongue and the oral cavity (as if the saxophonist is singing the pitch) whilst adopting a specific tongue position which allows the partials to sound underneath the note. This technique is demonstrated in figure 3 (Kientzy multiphonic number 115), where to the far right of column 7 the concert A5 is sounded before the other partials appear. When performing the multiphonic in this way the whole multiphonic is sounded but the highest note of the multiphonic is the most prominent (track 2).

Fig.3 Kientzy multiphonic number 115 for alto as taken from *Les Sons Multiples Aux Saxophones* (2003)



The multiphonic at the beginning of movement II, as shown in figure 2, can be seen as an echo of the final phrase of movement I (displayed in figure 4). The performer may wish to take this into account by performing the multiphonic with this note emphasised. Ensuring the prominence of this linking note is, however, problematic as the multiphonic requires such specificity in oral cavity manipulation to produce. It is noticeable when performing this multiphonic that, as with most multiphonics, the lower notes try to speak first as they are closer to the stronger fundamental pitch. In order to gauge where the multiphonic lies within the different tongue positions (described in chapter 2), the performer needs to learn the 'feel' of the tongue position in order to sound the multiphonic accurately. There is also

Fig.4 Edison Denisov Sonata for Alto Saxophone and Piano (1973) mvmt 1 bb.116-117



a noticeable change in lip position as the bottom lip needs to extend slightly further forward in order to produce the note, adopting a similar position as playing in the altissimo register. If these subtle changes cannot be memorised then an effect of 'fading in' the upper notes of the chord will be heard, as the performer searches through the partials and arrives at the correct sound. This would mean that the F#5 which links the first movement to the second would be the last note we hear, rather than the strongest note of the multiphonic. It could be argued that this 'fading in' effect is exactly what Denisov wanted as he has marked the multiphonic with hairpins rising from *piano* back down to *pianissimo* throughout the duration of the multiphonic. It is probable that in close collaboration with Jean-Marie Londeix (for whom the piece was written) Denisov was aware that this particular multiphonic could not be attacked with all partials sounding at such a low dynamic, and therefore the *crescendo* and *decrescendo* indication is used to indicate the 'fading in' and 'fading out' of this multiphonic.

In each of three existing recordings of Denisov's Sonata for Alto Saxophone (1973), the performers have chosen different approaches to the first multiphonic of movement II. Each require different tongue manipulations in order to achieve each effect. The recording by Dutch saxophonist Arno Bornkamp shows the use of the 'bottom upwards' approach during the first multiphonic (track 3). This interpretation allows Bornkamp to achieve a *niente* entry on the lowest fundamental, followed by a swell as the higher harmonics are brought in (which are naturally louder) before losing them again to complete his phrase. The lowest note in most multiphonics is usually the strongest sound and so Bornkamp uses this to his advantage by using subtone (a technique which is discussed in chapter 1 in the section entitled 'Embouchure techniques') to keep the beginning of his phrase quiet and then moving his tongue into position to complete the multiphonic following the contours of the hairpins.

In contrast to this British saxophonist John Harle decides to bring the multiphonic with all harmonics present as the score depicts, but by doing this he sacrifices the *pianissimo* marking of the first entry (track 4).

Track 5 of the accompanying CD is taken from a third recording of the movement by French saxophonist Claude Delangle, who can be heard starting the multiphonic on the highest partial (F#5), sounding the other partials after this note has been sounded. This 'top down' approach to the multiphonic is, in effect, the direct opposite of Bornkamp's interpretation.

These varied approaches show that a performer can display an awareness of the role a technique plays within a composition, whilst still retaining the freedom to manipulate the acoustical and temporal aspects of the passage to suit their individual interpretation, as Clarke (1995) suggests. It is the understanding and mastery of acoustical and physiological manipulations that allow the performer to manipulate extended techniques and thus retain interpretative control. If indeed the score is a representation of a sound that exists beyond the visual constraints of written music as Lester (1995) suggests, and that the resulting music can only be experienced by a listener in a single moment in time which cannot then be re-examined, the performer's choices of how to perform extended techniques based upon their understanding of the composition are significant. Each saxophonist performing Denisov's sonata has decided to highlight different relationships within the pitches of the opening multiphonic of Movement II*;* emphasising the difference of opinion as to the importance of specific relationships within the music. Each performer understands the extended technique sufficiently enough to manipulate how it sounds, using tongue position and embouchure adjustment to accurately create a sound that is appropriate for their interpretation. The relationship between the physical manipulation of extended techniques, and the artistic role this manipulation plays in the context of the composition as a whole, is important in underlining the artistic decisions a performer has made in order to realise an interpretation.

Chapter 1

An Investigation Into Materials Relating to the Usage of Extended Techniques Within Compositions with an Emphasis on Pedagogy, Repertoire and Research

Extended Woodwind Technique

One of the first major studies of extended techniques for woodwind instruments is Bruno Bartolozzi's *New Sounds for Woodwind* (1967), in which the author categorises 'new sound' techniques in two ways: monophonic and multiphonic possibilities. These categories cover techniques such as harmonics, multiphonics, quartertones and timbral manipulations by referring simply to their multiphonic or monophonic qualities. There are, however, many other variables involved in the production of these techniques which require more explanation and discussion than Bartolozzi provides in his single volume covering the four orchestral woodwind instruments. Expanding on Bartolozzi's observations are a number of instrument-specific manuals which explore the different techniques available to each instrument and offer some discussion regarding the main approaches to the alteration of the instrument's fundamental sound. In each of these texts the authors have presented tables of fingerings for both monophonic (harmonics/micro-tones) and multiphonic possibilities of the instrument in question and this presents the bulk of the information for the instrumentalist.

In *The Avant-Garde Flute* (1974) by Thomas Howell, the author presents the reader with a list of fingerings for no less than 1826 multiphonics, and descriptive notes which outline each multiphonic's individual behaviour. The list of fingerings that appear in *The Other Flute* (1989) by Robert Dick also demonstrate the reliance woodwind players have on fingerings by first presenting all possible alternative fingerings for the regular chromatic scale, and commenting through a simple key their relative effectiveness at varying dynamics. Dick also takes into account the strength of the air sound within each pitch, assigning the sound a number from 1 being slightly breathy to 5 being extremely breathy. A similar numerical legend is used in Dick's multiphonic charts with a numbering guide for ease of production where 1 is 'produced very easily with all pitches starting simultaneously' to 5 which is 'produced with great difficulty with a delay of 3 seconds or longer before all pitches sound' (Dick, 1989, p.viii). He goes on to outline further scales for stability and modulation before giving the reader his classification of multiphonics in relation to lip opening and tension. This classification is as follows:

> Class I: generally the lowest two pitches produced by a given fingering, usually forming an interval of a sixth to a tenth.
> Class II: generally the second and third lowest pitches produced by a given fingering, usually forming an interval of a fourth to sixth.
> Class III: generally the third and fourth lowest pitches produced by a given fingering, usually forming the interval of a third to fifth.
> Class IV: generally the fourth and fifth or fifth and sixth lowest pitches produced by a given fingering, usually forming an interval of a third to sixth.
> (R. Dick, 1989, p.viii)

This classification is indicative of the sorts of manipulations that can be achieved within multiphonics based on the flute and its particular harmonic series and method of sound production, whereas the reed player who plays on a closed tube which produces different harmonics must manipulate the sound using the tongue and throat rather than the lips. This difference is acknowledged in *The Techniques of Oboe Playing* (1994) by Peter Veale and Claus-Steffan Mahnkopf, wherein the authors include a diagram for each multiphonic indicating how much of the reed is to be in the mouth for each multiphonic to speak. This book also has many fingering charts, however, the sections that discuss the various techniques refer to them in a great deal more detail by taking into account the acoustics of the instrument. For example the authors present us with the following equation for multiphonics:

$$f = n\,A + m\,B \qquad n = 0, \pm1, \pm2, \pm3 \ldots \quad \text{up to approx. } 10$$

$$m = 0, \pm1, \pm2, \pm3 \ldots \quad \text{up to approx. } 6$$

$$\text{however, } f \text{ is always} > 0$$

Here the two sinusoids A and B are always treated with a secondary value of n and m respectively, and each of these secondary values can be plus or minus up to ten or six cents respectively in their intonation. This means that the frequency f is the result of various combination tones within the multiphonic as a result of heterodyne relationships; this phenomena and a further exploration of the resultant sounds will be covered in more detail in chapter 2, section 2. *New Directions for Clarinet* (1977) by Philip Rehfeldt also categorises multiphonics and applies that category within his fingering chart which shows the multiphonics possible from a lower fundamental. Rehfeldt also illustrates what Howell refers to as 'miscellaneous special effects' such as *glissandi* and *bisbigliando*, outlining what is possible on all sizes of clarinet for each technique. The manipulation of multiphonics is described in both Daniel Kientzy's *Les Sons Multiples Aux Saxophones* (2003) and Pierre-Yves Artaud's *La Flûte Multiphonique (*1995). Both of these books deal with multiphonic trills, harmonics within the multiphonic and embouchure control. The extensive array of techniques listed by Daniel Kientzy in his study *L'Art du Saxophon (*1993) taken from his full text *Saxologie* (2002, which has never been translated from its native French), outlines the possible techniques available to a composer, complemented by examples of their notation and a recording of each technique. This list of over 100 different techniques does not serve as a teaching aid to saxophonists; rather, it simply makes the reader aware of what can be achieved with no real detail of how the effect is to be executed. The introduction states that 'the present work is not a modern saxophone method (such a work has still to be written)... nonetheless [it] deals with no less than 100 playing techniques' (Kientzy, 1993 p.97). Books have been written that attempt to fill the gap outlined by Kientzy by providing exercises and excerpts from compositions as examples from which both composer and performer can learn. One such general technique book that is written as a tutor book for performers and composers alike is *The Techniques of Saxophone Playing* by Marcus Weiss and Giorgio Netti (2010) in which the authors categorise saxophone techniques as follows:

Table 1: Classifications of extended techniques as taken from Weiss & Netti (2010)

Single Tones	Microtones, eighth-tone scales, altissimo and timbral fingerings
Multiphonics	Basics, fingering charts, performance of multiphonics
Performance Techniques	Articulations, sound and embouchure techniques, teeth on the reed, trills and tremoli, harmonics, glissandi, key percussion and singing whilst playing

It is noteworthy that harmonics in Netti and Weiss' book are classed as a performance technique whereas other texts treat the harmonics as a fundamental skill on which other techniques are built. This demonstrates the dual nature of this text as being a learning aid to both performers who need to learn the technique and composers who may wish to employ it in a composition. A similar categorisation of technique is clear from the contents page of Londeix's book *Hello Mr. Sax!* (1989):

Table 2: Classifications of extended techniques as taken from Londeix (1989)

Pitch	Pitch, range, altissimo, trills and tremolos, 1/3, ¼ and 1/5 tones, simultaneous sounds or multiphonics, tuning
Timbre	Timbre, flutter-tonguing, bisbigliando, vibrato, trumpet-like sounds, key clicks and pad sounds, other timbres, aeolian sounds
Duration	Duration, continuous or circular breathing
Articulation	Most commonly used articulation
Volume	Soft dynamics for saxophone, dynamics
Attacks	Polymorphical transients of a musical tone, types of sounds which can be produced on the saxophone, staccato markings, musical examples

In both cases the authors seek to inform the reader of the sonic possibilities of the saxophone by suggesting fingerings and notations they think best suited to the task. Both texts share common ground in their identification of extended techniques which I will identify in four broad groups:

Table 3: Classifications of extended techniques as compiled as a combination of Weiss & Netti (2010) and Londeix's (1989) suggestions

Pitch	Altissimo Harmonics (Aeolian Sounds) Mictrotones
Multiple Pitch	Singing and playing Multiphonics
Timbre Techniques	Timbral fingerings (Bisbigliando) Embouchures techniques Key percussion Flutter tongue
Duration Techniques	Slap tongue (short duration) Circular breathing (long duration)

Pitch Techniques

In order to expand on the techniques described in the above table, this next section will discuss each of the extended techniques in more detail with reference to both pedagogical texts, and the repertoire which use them.

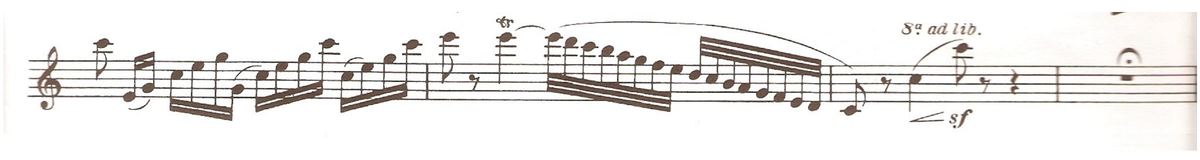
Altissimo

One of the earliest modifications of technique in the saxophone repertoire is that of extending the range beyond the limitation of the instrument and into the altissimo register. It is thought that the addition of the extra key which allows saxophonists to hit the note F#6 came into standard production in the 1950s with the advent of Selmer's 'Mark VI' model. Before this saxophonists could only achieve the note F6 without making any alterations to their technique. Evidence of altissimo writing appears as early as 1935 with Jacques Ibert's *Concertino Da Camera*. Figure 1.1 shows a passage from movement II of the work which requires the saxophone to play nearly a whole octave above the established range of the instrument. Altissimo writing can also be found during the closing phrases of Glazunov's Concerto for Alto Saxophone written around the same time (see figure 1.2).

Fig.1.1 Jaques Ibert *Concertino da Camera* Movement II bb.24-30

Both of these pieces were written for the saxophonist Sigurd Rascher who was pioneering altissimo playing around this time, leading to the publication of his book *Top Tones for*

Fig.1.2 Alexander Glavunov Concerto for Alto Saxophone figure 55 bb.4-7



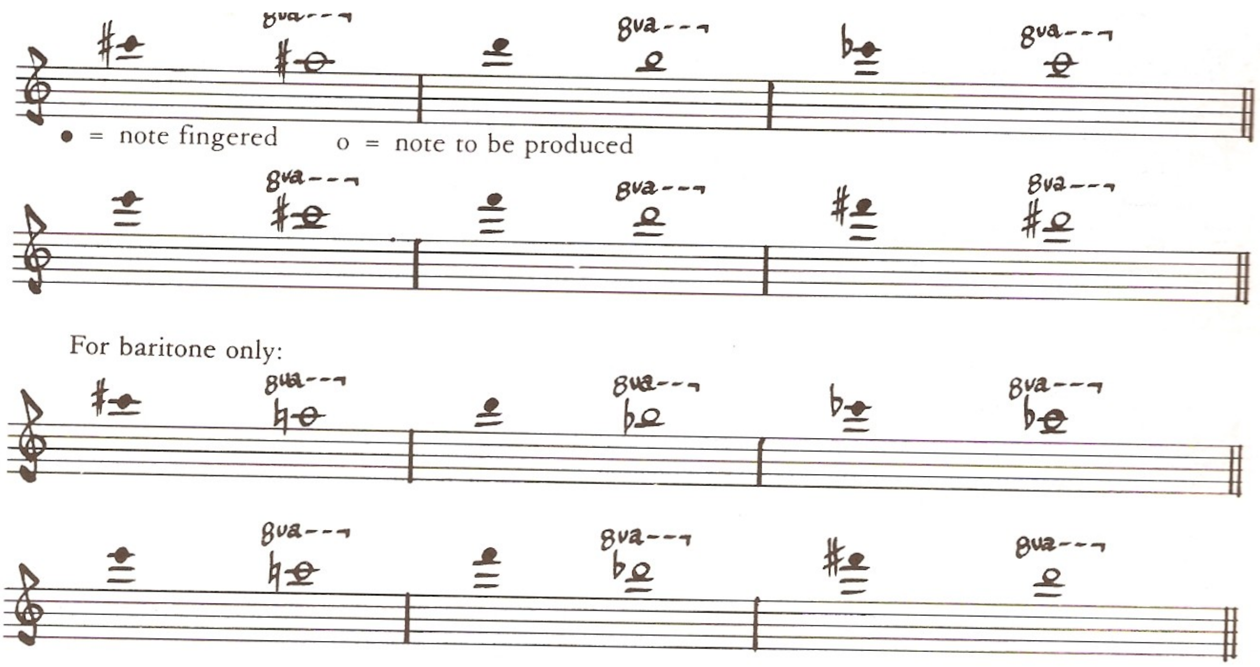
the Saxophone (1941) in which he presented saxophonists with the first complete methodology by which this extended range could be reached. In the foreword to the first edition of this book, Rascher explains: 'the production of tones higher than top F is based on the principle of “harmonics”, so called because the first six tones in any overtone gamut form a major chord' (1941 p.4). In order to continue ascending into the altissimo register the saxophonist must learn a completely different style of blowing their instrument which involves correct placement of the tongue and larynx. This physical manipulation of the air stream results in the tone being split into its harmonics, and as Rascher goes on to state in the foreword to the second edition of the same book (1961):

> I have spoken to many an enthusiastic saxophone player who aimed for a high register. Without exception, the student who fails to comprehend the prime importance of the development of the “inner ear” - “tone imagination”, “concept of tone” - also fails to produce, let alone master, the high register'
> (Rascher, 1961 p.4).

Eugene Rousseau's book *Saxophone High Tones* (1978) describes the technique of over-blowing sixths whilst in the upper register of the saxophone in order to obtain the altissimo range as depicted in the chart in figure 1.3. Rousseau claims that 'the great value of this technique is three-fold: (1) as an aid for the development of a facility in playing high tones; (2) as a marvellous way in which to develop embouchure and air control; (3) as an enormous help in enhancing the saxophone tones in the range C#3 to F#3' (Rousseau, 1978 p.19). It is true that the established fingerings for these tones are versions of the lower fundamental depicted in figure 1.3.

Steve Lacy notes in his book *Findings* (1994) that 'each harmonic overtone demands its own formula of diaphragmatic pressure, labial position, wind direction, tongue placement, hearing conception and the perception after. It is necessary to determine all of these elements, one by one, over the course of years, until they become internalised and automatic' (Lacy, 1994 p.17). In this statement Lacy describes the processes of physiological manipulation a saxophonist must master in order to execute this technique. However, he does not elaborate on this list of specific changes instead asserting that it will take years to learn. It is common in such texts for the author to mention these changes but not to acknowledge exactly what the saxophonist needs to alter for these techniques. Specific processes pertaining to the altissimo range such as tongue position, throat position,

Fig.1.3 Technique of overblowing sixths taken from Eugene Rousseau's *Saxophone High Tones* (1978)

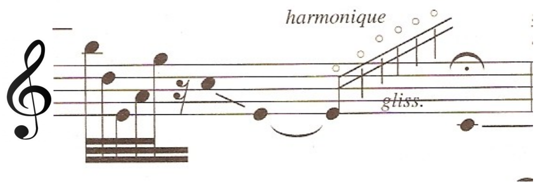


'inner ear' and harmonics will be explored in more detail in chapter 2, section 3 of this thesis. The altissimo register has now become a feature of saxophone technique at higher education level, and is extensively used in compositions. It is still, however, not a requirement for amateur musicians and students to pass practical examinations on the instrument; indeed the main UK music examining board does not make the requirement of a two octave F# major or minor scale in their top grade (ABRSM exam syllabus 2011-2013), even though most saxophones are capable of the note without needing to play in the altissimo register.

Harmonics (Aeolian Sounds)

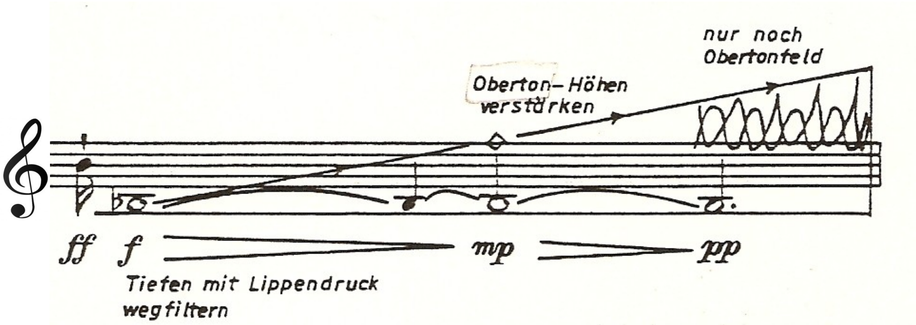
Even though harmonics have been discussed as the foundation on which the altissimo register is based, there are instances of the harmonic series being utilised in compositions. Yoshimatsu asks for a harmonic glissando on the note E2 in his *Fuzzy Bird Sonata* (1995, figure 1.4, track 6). It is also one of the closing gestures in Nicolas A. Huber's *Aus Schmerz und Trauer* (1982), in which he instructs the saxophonist to reinforce the high overtones ('Oberton-Hohen verstarken') by applying pressure with the lip ('Tiefen mit Lippendruck wegfiltern') until only the overtones remain ('nur noch Obertonfeld', track 7).

Fig.1.4 Takashi Yoshimatsu *Fuzzy Bird Sonata* (1995) p.1 line 4



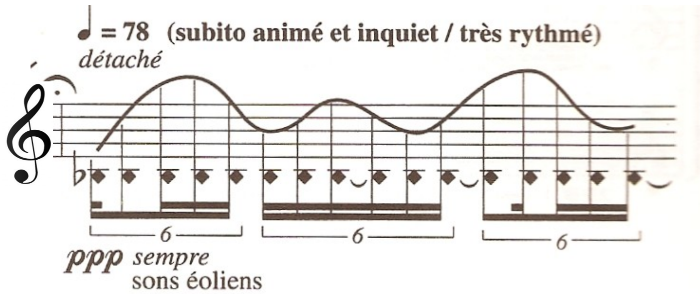
Like Rascher and Rousseau the composer notates the fundamental to be used, with the second partial suggested and then a special graphic for the overtones (figure 1.5). This glissando is achieved by moving very quickly through the tongue positions required for each partial, which involves moving the tongue upward and forward in the mouth. This action constricts the flow of air into the instrument by increasing

Fig.1.5 Nicolaus A. Huber *Aus Schmerz und Trauer* (1982) p.11 b.5



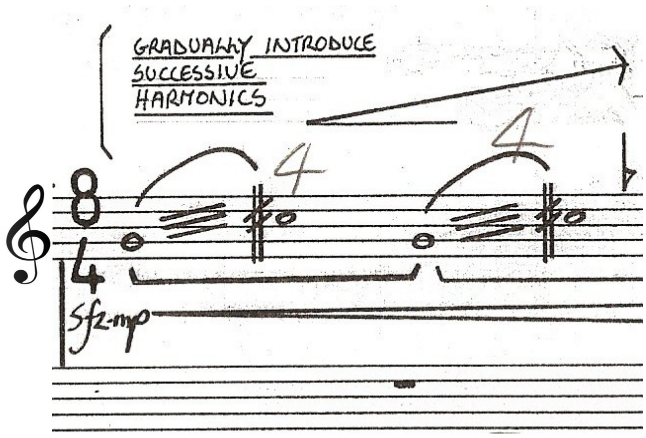
the pressure surrounding it thus increasing the velocity of the air. This principle of fluid dynamics will also be described in more detail in chapter 2, section 3. Using the throat and tongue in this way makes the saxophone's harmonic series very flexible thus allowing the saxophonist to easily glissando in this high register. This technique is used in Fuminori Tanada's *Mysterious Morning III* (1996, figure 1.6) to create 'aeolian sounds' following a drawn line for the pitches to be sounded to a specific rhythm (track 8).

Fig.1.6 Fuminori Tanada *Mysterious Morning III* (1996) p.7 line 7



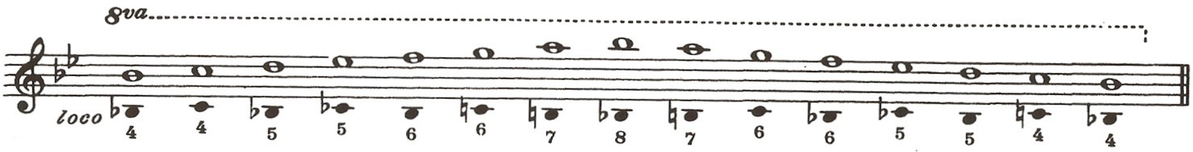
Mike Vaughan's *Ensphered* (1990) also uses this technique within a tremolo to emulate the electronic sounds of his tape part. Vaughan notates the tremolo and includes the direction 'gradually introduce successive harmonics' and then 'reduce harmonics' (figure 1.7, track 9). Both Rascher's and Rousseau's books acknowledge the throat and embouchure manipulations that need to occur in order to play the harmonic series.

Fig.1.7 Mike Vaughan *Ensphered* (1990) b.9



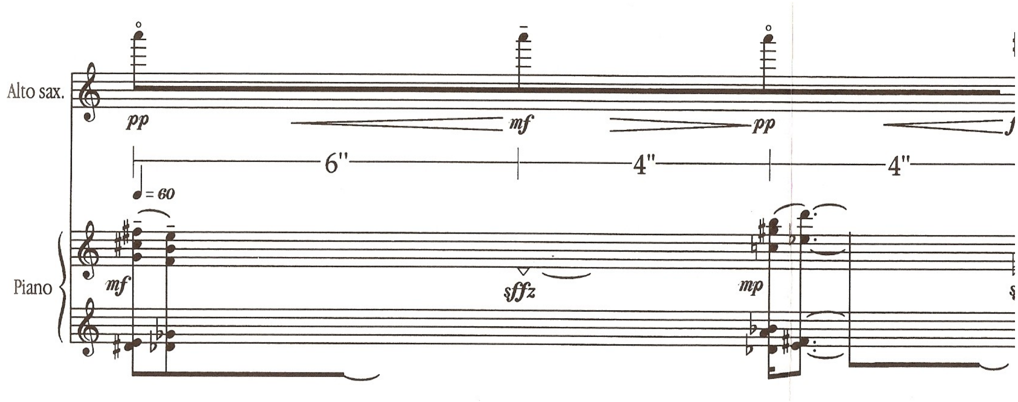
To this end Rascher introduces the concept of playing in the altissimo register using different fundamentals (figure 1.8). This technique demonstrates how partials from a different fundamental can be used to add a different tone colour to the passage, much like a violin

Fig.1.8 Demonstration of playing on different partials (represented numerically) from Sigurd Rascher's *Top Tones for the Saxophone* (1941)



would when using natural harmonics. This technique is used in Yoshihisa Taïra's *Pénombres VI* (1996) where the first three notes in the saxophone part are different versions of the note A6, the regular fingering (an overblown C6 as in Rascher and Rousseau's charts) and a harmonic version which can be played as the fourth partial of D4. This highlights the different textures between these two versions of the same pitch (figure 1.9, track 10).

Fig.1.9 Yoshihisa Taïra *Pénombres VI* (1996) p.1 line 1



Microtones

Due to the mechanics of the saxophone, and the absence of open tone holes, the microtonal possibilities of the instrument are somewhat limited. Londeix states that 'because of the current state of instrumental manufacturing, 1/3, 1/4 and 1/5 tones and micro-intervals cannot be obtained on all saxophones' (Londeix, 1989 p.24). The saxophone is capable of playing microtones by flattening the note above the desired microtone, thereby an F can become an F quarter-tone flat by the addition of a key lower than the pitch (this principle is described in greater detail in chapter 2, section 2). Because of these reasons the instrument is simply incapable of producing certain quarter-and-eighth-tones.

Weiss & Netti state that 'with the exception of a few tones in the lower register (approximately the lowest fifth of the saxophone's range), as well as the microtones between G and G# (for purely mechanical reasons), quartertone as well as eighth-tones are possible on the saxophone' (Weiss and Netti, 2010 p.15). The authors go on to explain how:

> for the quarter-tone between G and G#, there is no "standard" fingering. One can, however, eliminate the mechanical connection from G to C#, as well as the closing mechanism of the G# key. If one prefers not to do this, the only possibility remaining, besides pure embouchure correction (letting the G# fall by a quarter-tone), is to finger a g# and let the fingernail of the index finger of the right hand on the edge of the tone hole of the F or F# key and closing it

until it touches the fingernail. This fingering with half key is complicated, but it is, in fact, a fingering

(Weiss and Netti, 2010 p.15)

The solution I use for this is indeed an alteration of the mechanism surrounding the G# key (as described in the next chapter). However, examples of embouchure correction can be seen in Denisov's Sonata for Alto Saxophone (1973, figure 1.10). Londeix and Denisov collaborated closely on this work and so it is not surprising to find the instruction '*Lâcher les lèvres*' appearing in Londeix's book in regards to quartertones. It is thought that Denisov's Sonata is amongst the first works to use quartertones in the saxophone's repertoire, and

Fig.1.10 Edison Denisov Sonata for Alto Saxophone and Piano (1973) movement II line 4

since then these microtones have become a common tool for composers. Ryo Noda's compositions use micro-intervals in close juxtaposition with tempered pitches to highlight the sonic difference (figure 1.11). In a similar way microtones are used in Ichiro Nodaira's *Arabesque III* (1983) to highlight the tempered nature of the piano. Figure 1.12 demonstrates the use of dissonance between the saxophone's C three quartertones sharp and the piano's C sharps, giving the passage the effect of a descending microtonal scale between the piano's D, the saxophone's C three quartertones sharp and the piano's C sharp. Fuminori Tanada's *Mysterious* Morning *III* (1996) uses microtones to highlight its main theme of ascending and descending microtonal scales and trills/tremolos.

Fig.1.11 Ryo Noda *Maï* (1975) p.1 line 1 and p.4 line 2

Figure 1.13 shows the notation Tanada uses for his ascending micro-tonal trills, highlighting the pitches over the rhythmic duration of each trill. Tanada uses different notations throughout the work depending on his desired effect of 'anxiousness' as stated in his notes; figure 1.13 also demonstrates this notation. To this end a performer can choose between alternate fingering systems to alter the sonic behaviour of these microtones, which can highlight the anxiousness that the composer wishes the performer to convey.

Fig.1.12 Ichiro Nodaira *Arabesque III* (1983) b.130

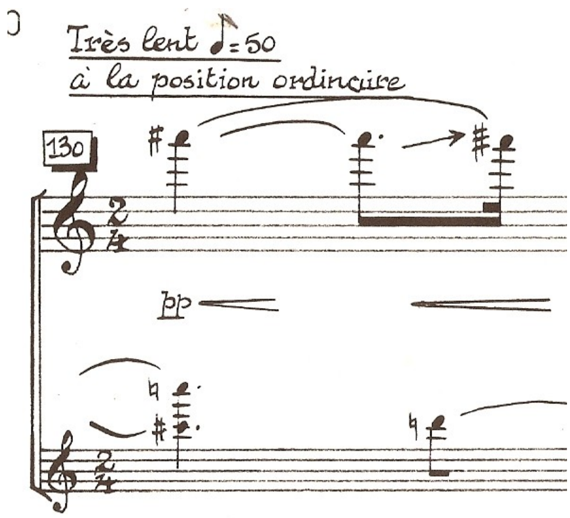
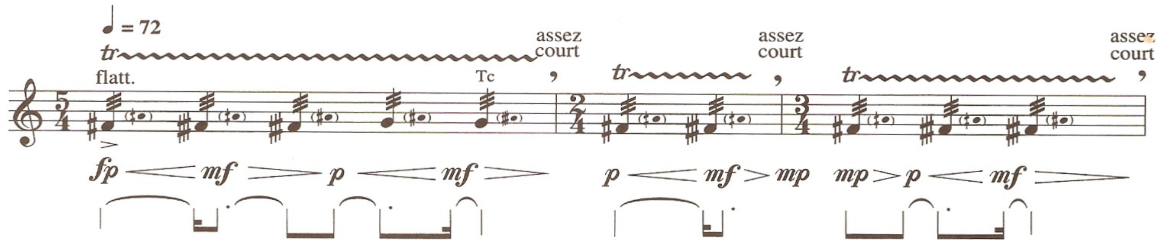


Fig.1.13 Fuminori Tanada *Mysterious Morning III* (1996) p.2 line 6



Multiphonic Techniques

Singing and Playing

It is common for saxophonists in rock, pop and jazz music to vary the timbre of their instrument by humming or singing whilst they play. This technique which is referred to in Delangle and Michat's article *The Contemporary Saxophone* in *The Cambridge Companion to the Saxophone* (ed. Richard Ingham, 1998) as 'growling' is well established in all styles of saxophone playing. In order to achieve the growl the instrumentalist does not need to be specific in their vocalisation in order to change the timbre of their instrument. Composers have, however, used this technique more imaginatively in order to create contrapuntal or homogenous musical lines between voice and saxophone, or to match both pitches closely together in order to achieve beating patterns within the sound. An example of both of these utilisations can be found in Tanada's *Mysterious Morning III* (1996, track 11). In figure 1.14 the saxophonist is asked to follow the descending demisemiquaver motif with their voice, this colours the sound of a passage which is also being played using flutter-tonguing thus distorting the pitch even further. Then in figure 1.15 the composer has notated the vocal pitch to be the same as the saxophone's pitch yet either up or down a microtone (track 12). The composer indicates that 'the voice part should be sung very

Fig.1.14 Fuminori Tanada *Mysterious Morning III* (1996) p.3 line 1

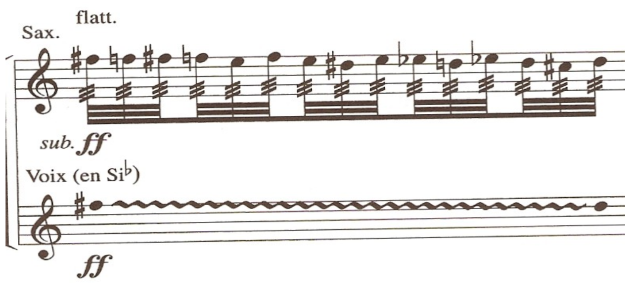
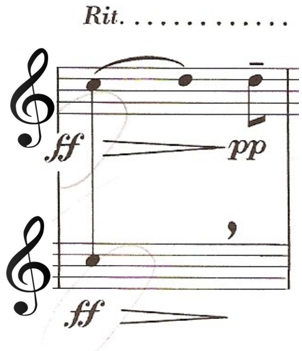


Fig.1.15 Fuminori Tanada *Mysterious Morning III* (1996) p.10 line 4

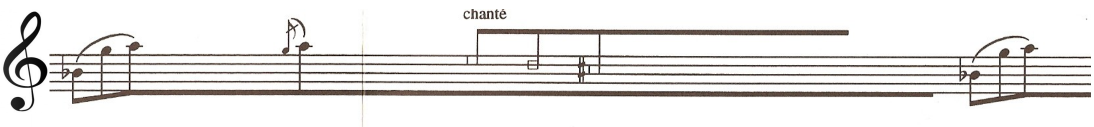
slightly higher or lower than the instrumental line so as to create beats' (Nodira, 1996). Other works use the instrumentalist's voice to augment the sound of the passage as on page 4 of Betsy Jolas' *Épisode Quatrième* (1983). Here the saxophonist is to sing in unison with the instrument whilst the instrument shifts up one tone creating a major second interval as in figure 1.16 (track 13).

Fig.1.16 Betsy Jolas *Épisode Quatrième* (1983) p.4 line 5



The intervallic nature of singing and playing is further exploited in figure 1.17 of the same piece where the sung interval expands to a minor sixth above the saxophone. This is one way that composers can achieve intervals whilst composing for a monophonic instrument; however, singing or 'chanté' can also be used in a melodic fashion as shown in Taïra's *Pénombres VI* (1996, track 14).

Fig.1.17 Yoshihisa Taïra *Pénombres VI* (1996) p.8 line 3



Multiphonics

In a literal sense the act of singing and playing could be seen as a multiphonic as there are indeed multiple discernible sounds. However, singing and playing requires two separate resonators to create each sound: the vocal cords of the saxophonist and the reed of the instrument. The phenomena of multiphonics in the sense of instrumental technique involves multiple discernible sounds from a single resonator - the saxophone's reed. The saxophone is capable of creating a number of multiphonic 'chords' that are produced through a combination of special fingerings and specific air-flow/tongue placement so as to create a disturbance in the air column that produces multiple sounds simultaneously.

These multiphonics by their very nature can be very delicate to produce, requiring a large amount of specificity in the saxophonist's preparation for them to sound at all. This fact very often limits the overall dynamic level at which a multiphonic can be produced before the phenomena becomes unstable, depending on whether the multiphonic is an unstable dyad or a more stable spread of notes, typically involving the interval of a minor ninth or minor twelfth. It is often necessary to classify the multiphonics in some way in order to contextualize them in a performers practise regime. John Gross does this in his book *Multiphonics for the Saxophone* (1998) by referring to the amount of discernible tones that can be heard in each multiphonic and splitting them into three groups: '3-noters', '2-noters' and '4-and More-noters'. The author also provides a rough indication of the tones to be expected but vitally he indicates a 'target note' at which the saxophonist should pitch the multiphonic in order for it to sound. This is important because the specific manipulation needed within the oral cavity of the saxophonist is crucial in the production of multiphonics just as it is in the production of harmonics, and this manipulation can often be achieved by imagining the singing of a note and thus tuning the vocal tract; a concept that will be explored in chapter 2, section 3. Gross' book is unique in that it does not separate multiphonics by type of saxophone, instead it asserts that each multiphonic can be performed on each saxophone relying heavily on the target note and therefore the oral cavity manipulation.

Other books which catalogue multiphonics do so by providing detailed microtonal transcriptions of each sound. Londeix's *Hello! Mr. Sax* (1989) provides a number of multiphonic fingerings for each type of saxophone from soprano to baritone. These multiphonics are ordered in groups of fingering types which demonstrates how the addition of a single key can, in many instances, transform one multiphonic into another. As these multiphonics are all based on fundamental tones this system of organisation results in the gradual ascension of the resultant multiphonics. Londeix also includes dynamic levels at which the multiphonics can be performed, noting that the sounds have a tendency to 'split' when these dynamic limitations are breached. This is also noted in Kientzy's *Les Sons Multiples Aux Saxophones* (2003) in which the author presents the multiphonics in a table which includes: written and sounding pitches, ease of repetition, fingering, trill possibilities and possible separation within the sounds. There are, however, only limited attempts to indicate how the performer is to achieve these possible gestures, other than an indication to expose more of the reed into the mouth, or that a sound produces an airy tone. Kientzy's book lists over one hundred multiphonics for each size of saxophone from sopranino to bass in this way, and its level of detail has made it invaluable to composers who wish to use multiphonics in their work. Building on the detail of Kientzy is Weiss and Netti's book (2010) which goes further into describing the resultant sound of each fingering as dictated by the saxophonist's oral preparation and fingering combinations. The way Weiss and Netti do this is through the use of symbols which signify a multiphonic type, the basic incarnation of which is laid out in the following table.

Table 4: Basic classifications of multiphonics as taken from Weiss & Netti (2010)

Fingering tube without openings; conventional fingerings (low Bb, B, C, C#)

A	Layer of natural overtones over a fundamental

Fingering tube with one or more openings; non-conventional fingerings

B	Sound with strong oscillation
C	Wide dyad, stable
D	Aggregate of two or more partials over a fundamental
E	Narrow dyad

This classification of the multiphonic goes a long way to indicate the timbre and sound of the multiphonic as well as giving specific notations for each. The way composers have used multiphonics has developed over the last forty years, as Weiss & Netti remarks: 'what began as the use of opaque blocks of sound functioning as contrast or even interference within the flow of monodic music has developed, in certain cases, into a material that has become fully

Table 5: Further classifications of extended techniques as taken from Weiss & Netti (2010)

Type	Track on the CD	Description
Ba	15	Detuned octave and twelfth, creating a stable oscillation, open and fast; p-ff
CE	16	Dyad between a fourth and fifth' stable; p-ff
Ce	17	Dyad between a minor sixth and seventh, stable; pp-p
Cb	18	Approximately an octave, with the possible presence of the twelfth,

		usually unstable; pp-p
C	19	Between a minor ninth and an eleventh (octave + fourth), stable; pp-mp
D/B	20	Wide multiphonic, usually built on a minor ninth (also second), partly oscillating; mp-ff
Da	21	Wide multiphonic, usually built on a ninth (also tenth, third or fourth), stable; p-ff
E	22	Triads; ppp-p
Eb	23	Seconds, as minor seconds usually oscillating strongly, with the possible presence of a low fundamental tone ppp; ppp-mp

integrated within the musical discourse' (Weiss & Netti, 2010 p.57). This is true of some earlier compositions where the multiphonic interest in a phrase is almost entirely in the interest of creating a 'special effect' as in Jindrich Feld's Sonata (1990). Movement three features a passage which uses multiphonics based on certain fundamentals (mostly 'B' type as above) to complete the phrase. However, the ossia of optional flutter tonguing suggests that the composer requires a textural change to the fundamental rather than the addition of specific partials above that fundamental (figure 1.18). Also the use of in-specific multiphonics in the works of Joe Cutler, where the composer stipulates that the performer should play multiphonics on a stipulated fundamental in works such as *Sal's Sax* (1995) and *Screaming 229a (*1996), suggests an interest in the timbral effect of multiphonics, rather than the specific intervals inherent within the phenomena.

As Weiss & Netti have stated above, multiphonics have been embraced by composers largely in two ways: as a 'block' of sound interrupting the line of music or as an integrated sound. The use of multiphonics as a 'block' of sound can be found in the second movement of Denisov's Sonata for Alto Saxophone and Piano (1973) where the composer uses multiphonics of type Ba alongside monodic lines which share pitches with the multiphonic. Nicolaus A. Huber uses multiphonics to introduce or end sections in his work *Aus Schmerz und Trauer* (1982). These multiphonics are long 'block' chords of type Ba creating a strident oscillation and a de-tuned octave and a twelfth. Other examples of 'block' multiphonics are also found in Ryo Noda's *Maï* (1975) where the penultimate section is comprised entirely of type Ba multiphonics which share pitches at the extremities of the multiphonic but change subtly in the inner pitches (Figure 1.19).

Fig.1.18 Jindrich Feld Sonata for Alto Saxophone (1990) Movement III bb.48-61

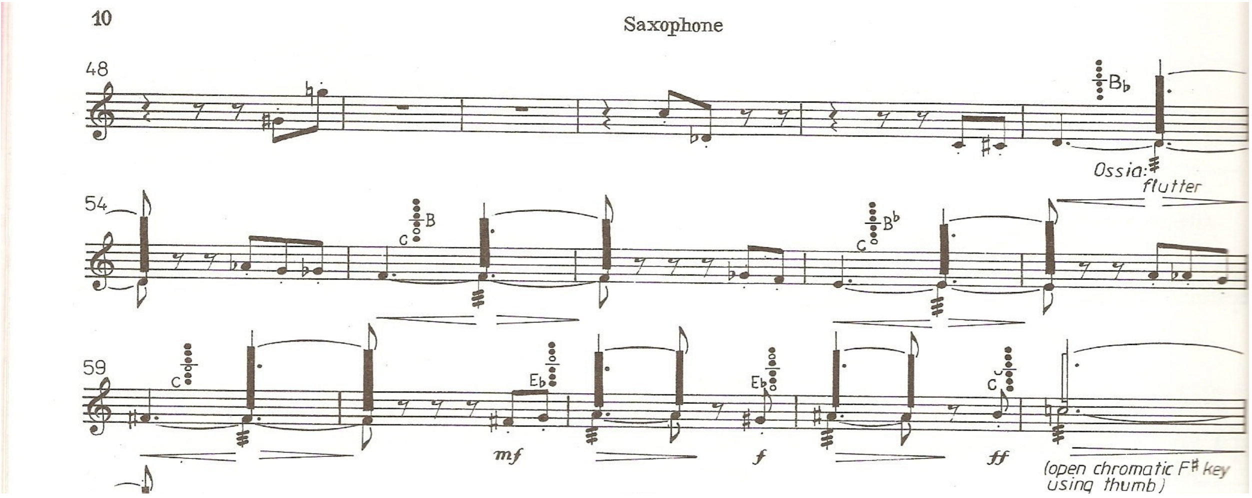
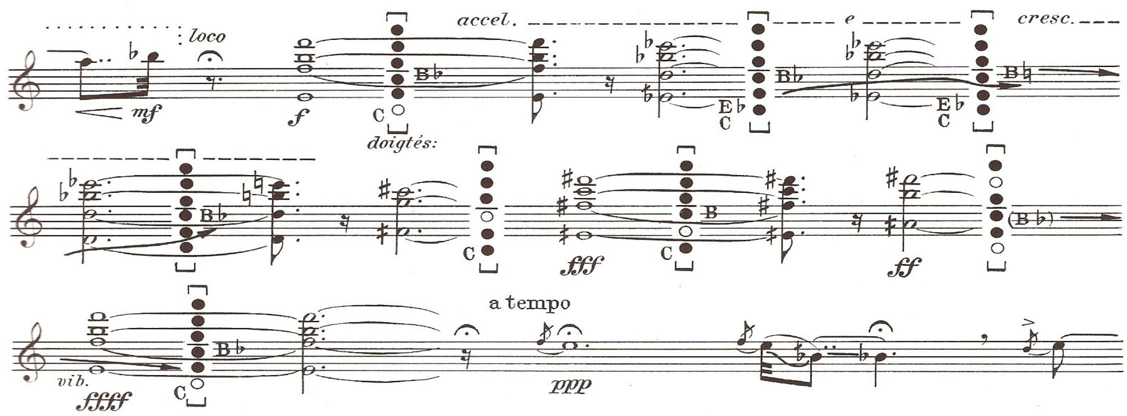


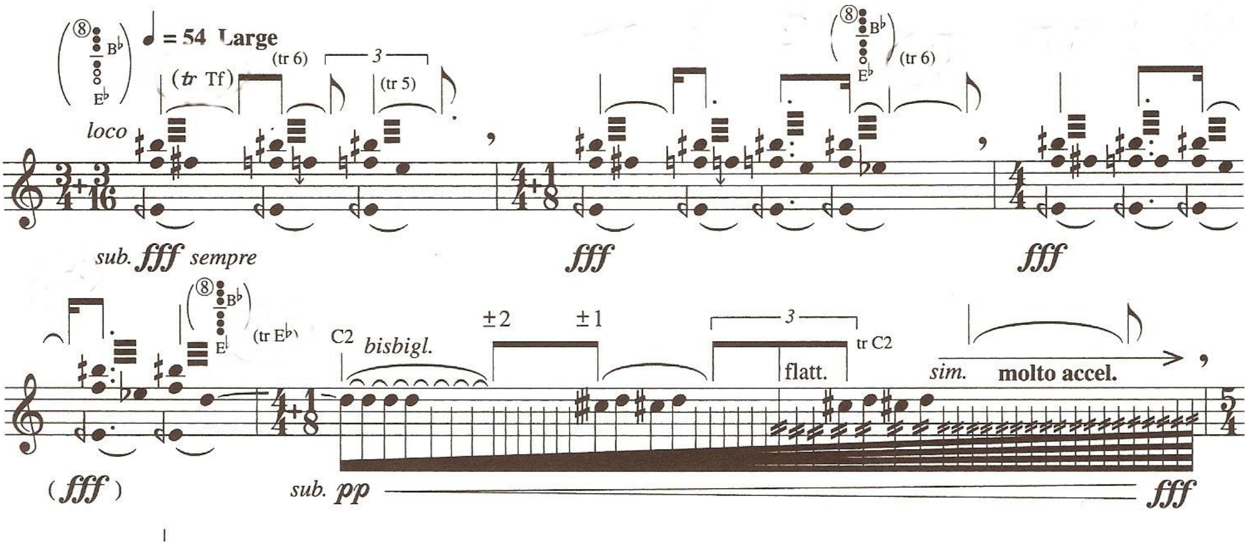
Fig.1.19 Ryo Noda *Maï* (1975) p.4 lines 3-5



Fuminori Tanada uses type Ba multiphonics in his composition *Mysterious morning III* (1996) to further develop his theme of descending trills and tremolos. Each multiphonic he uses shares common extremities of pitch (the top and bottom) yet the inner parts descend in semitones. This is a solid example of a grouping of fingerings which alter multiphonics of a similar type (Figure 1.20). Tanada also demonstrates the malleability of multiphonics of this type through the use of isolating a single pitch within it. The multiphonic in figure 1.21

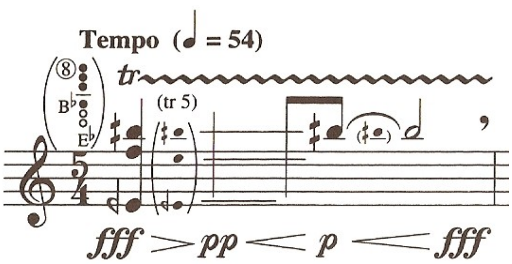
demonstrates a particular feature of type Ba multiphonics in that a single tone can be isolated at the top extremity of the multiphonic by maintaining the fingering and altering

Fig.1.20 Fuminori Tanada *Mysterious Morning III* (1996) p.6 lines 3 and 4



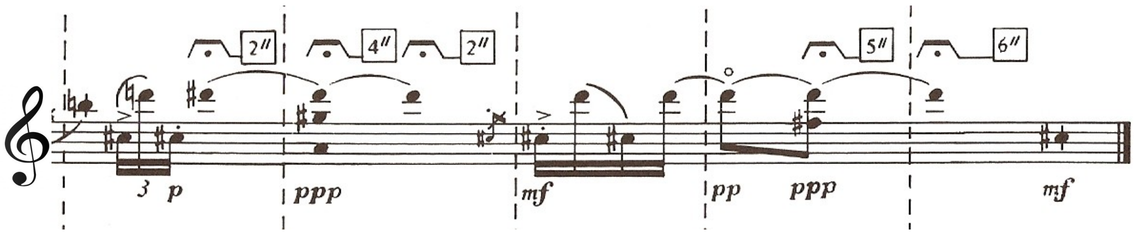
the tongue position alone (track 24). The technique is used in this instance alongside the trill which features throughout the piece, and so without altering the fingering both the top pitch of the multiphonic and the trill are maintained. Similar isolation of single pitches can

Fig.1.21 Fuminori Tanada *Mysterious morning III (*1996) p.6 line 5



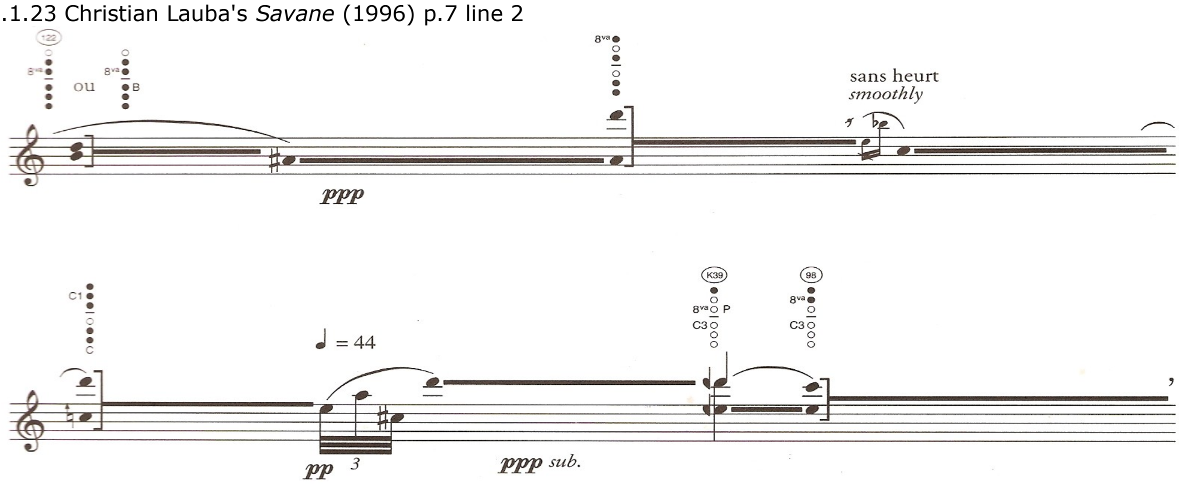
be found in Claude Delangle's transcription of Berio's *Sequenza VII* (1969), renamed *Sequenza VIIb* and transcribed in 2003. In this example (figure 1.22, track 25) the pitch D3 is common to two different multiphonics.

Fig.1.22 Luciano Berio *Sequenza VIIb* (2003) line 13



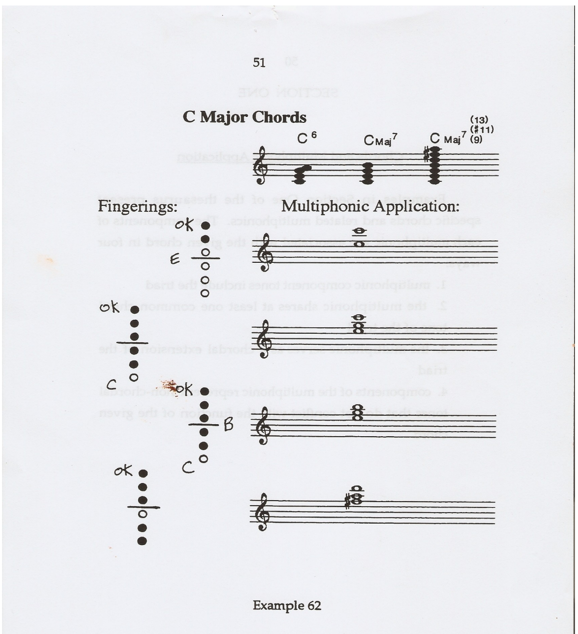
Multiphonics of a different type are explored alongside type Ba multiphonics in Christian Lauba's *Savane*, one of his *Neuf Études* (1996). In this piece multiphonics of type C and Cb (unstable dyads of an octave or a twelfth) are used in the first section of the piece. These dyads then contract into multiphonics of type CE and Ce (minor fourth, fifth, sixth or seventh dyads) until reaching the more familiar type Ba multiphonic. Lauba also includes multiphonics of type Eb creating intervals of a major or minor second or third; this is the smallest interval in the piece and the point at which his contraction of multiphonics ends (figure 1.23). The main feature of this composition is the usage of multiphonics of various types to create an ever contracting set of intervals throughout the piece.

Fig.1.23 Christian Lauba's *Savane* (1996) p.7 line 2



John Coltrane's track *Harmonique* from his album *Coltrane Jazz* (1961, track 26) includes a dyad of type Ce integrated into the melodic line. This pioneering use of the technique is an enduring testament to the melodic capabilities of the technique, appearing on record ten years before the use of multiphonics in Denisov's Sonata for Alto Saxophone and Piano (1973). In his study entitled *A Thesaurus of Saxophone Multiphonics and a Guide to their Practical Application* (1998) Boyd Allan Phelps catalogues the usage of multiphonics alongside conventional jazz harmony, implying that multiphonics can be used as chords or double stops. There are perhaps inevitable problems with this usage as the multiphonic timbre is often complex, the result of multiple harmonic spectra being produced simultaneously. Phelps' theory gets around this problem by implying multiple extensions to the chords in order for the multiphonic to fit. Figure 1.24 shows Phelps' suggested multiphonics for C minor and C major chords. Immediately we can see that the chords become increasingly extended up to C minor seven added ninth and eleventh. This extension explains the presence of an F and D in the first example. There then follows some examples of tonic/dominant chords which would be more useful; however, when performing the C major multiphonics the ear can detect that the presence of an F which would be an eleventh extension, not a sharp eleven as stated. It is possible that Bert Wilson, the saxophonist with whom Phelps worked, was able to suppress these tones with his tongue and throat placement. Phelps' catalogue also includes noted instances of audible additional tones by his indication of 'non-chord tones' as in figure 1.25. These are tones that Phelps and Wilson are willing to ignore in order to outline the harmony indicated, suggesting that these multiphonics are more timbral in nature than requiring exact tuning.

Fig.1.24 Suggested multiphonics to fit over C major and C minor chords taken from Phelps' *A Thesaurus of Saxophone Multiphonics and a Guide to their Practical Application* (1998)



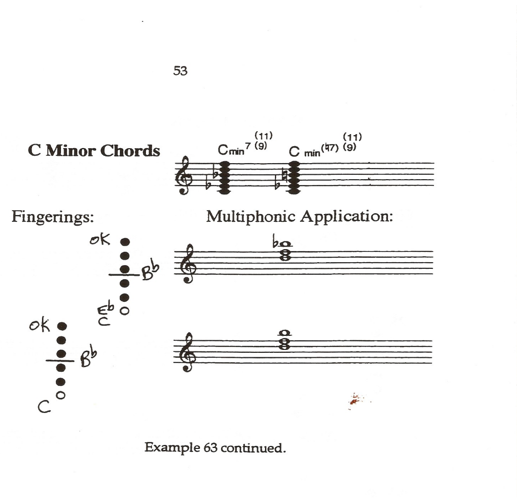
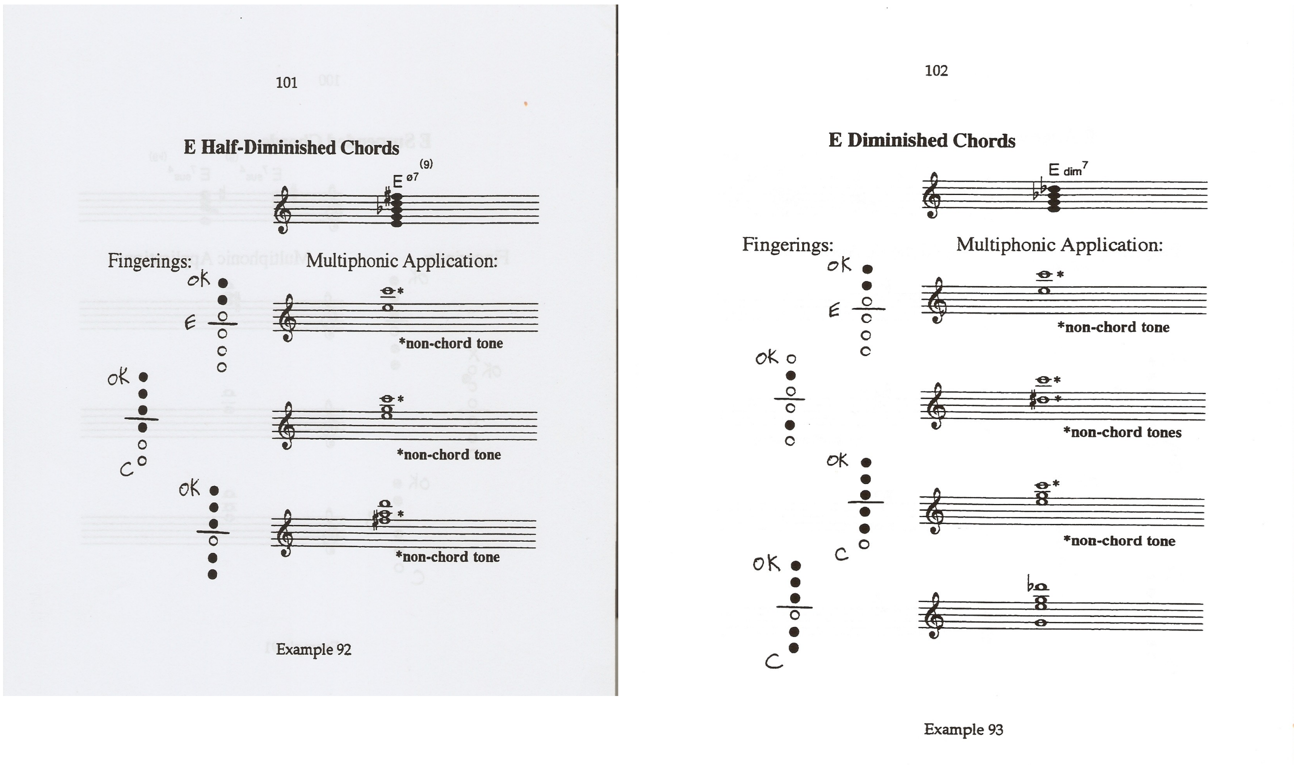


Fig.1.25 Suggested multiphonics to fit over E half-diminished and E diminished chords taken from Phelps' *A Thesaurus of Saxophone Multiphonics and a Guide to their Practical Application* (1998)

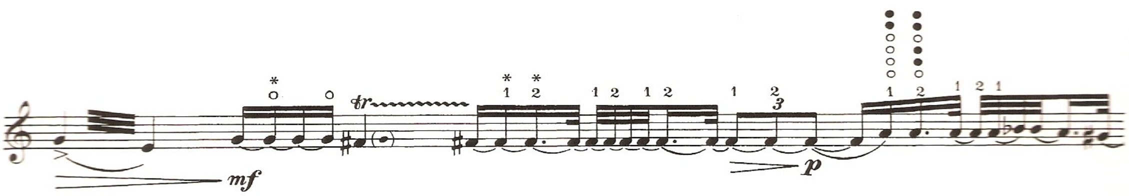


Timbre Techniques

Timbral Fingerings and Bisbigliando

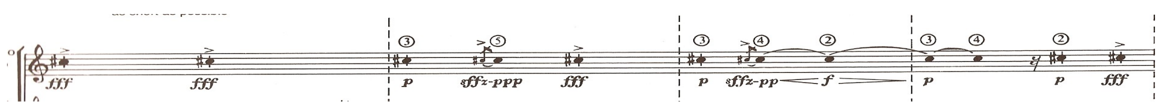
Timbral fingerings (or 'false' fingerings) are fingering combinations that allow for a single tone to be sounded with various timbres, and are a mixture of harmonics as described previously and the use of other keys to flatten or sharpen the note to produce the effect of a 'brighter' or 'darker' sound respectively. Ronald Caravan outlines how alternative fingerings are used in conventional repertoire for reasons of both intonation and timbre: 'the issues of pitch and timbre should influence the decision of the performer regarding when to employ an alternative fingering. In respect to pitch, the musician can take advantage of the minute differences which occur among the various fingering alternatives... and achieve shadings which may be appropriate or even necessary in numerous situations' (Caravan, 1974 p.164). Caravan goes on to explain that 'selecting an alternative fingering because of timbre considerations is an important but less frequently employed practice. Often a fingering other than that which the performer usually uses for a particular note will enable him to execute a passage with greater homogeneity of tone quality' (Caravan, 1974 p.170). Never is this more apparent than when a passage goes over the break of the instrument. Here the saxophonist is encouraged to use the first partial of C4 or C#4 (often known as 'closed' C or C#) to maintain the timbre of the passage. Caravan also acknowledges the importance of alternative or 'false' fingerings as 'raw material for composers'. Luciano Berio's *Sequenza IXb* (1980) uses the technique as a rhythmic device, wherein the tone is coloured to highlight the rhythmic content of the phrase (see figure 1.26). Berio's *Sequenza VIIb* (2003) uses the technique in a slightly different way; the

Fig.1.26 Luciano Berio *Sequenza Ixb* (1980) p.5 line 7



saxophonist is required to find five alternative fingerings for the note C#5 which makes up the material for most of the first line of the piece (figure 1.27). This pitch variance is the nucleus from which the work grows ever outwards but ultimately returns back to this important pitch. A similar device is used in Nicolaus A. Huber's *Aus Schmerz und Trauer* (1982) where the composer has marked the tone C in certain passages with numbers from

Fig.1.27 Luciano Berio *Sequenza VIIb* (2003) line 13



one to eight, indicating that the higher the number the darker the resultant sound should be from normal. This device is also present in the work *Maknongan* (1986) by Giacinto Scelsi, where the difference between light ('cupo') and dark ('chiaro') over a single tone is executed by using false fingerings on the baritone saxophone.

Embouchure Techniques

Embouchure techniques are techniques which alter the sound through manipulation of the player's embouchure (the placement and manipulation of the lips) such as falls, smears, subtone and vibrato. It is uncommon, yet not unheard of, for the composer to write for the saxophone to be played without a mouthpiece in which case ram-tongue and trumpet sound techniques can be employed. Ram-tongue simply consists of the saxophonist blowing down the open crook of the saxophone and inserting their tongue at a high velocity into the opening creating a percussive and airy pitched sound that can be altered by the keys. The trumpet sound also works simply by operating the open end of the saxophone like a trumpet by vibrating the lips directly into the opening. The resultant pitch can then also be controlled by the keys, effectively turning it into an ophicleide-like instrument. Whilst both of these techniques require the mouthpiece to be absent (although some players have mastered the ram-tongue technique by inserting the tongue onto the reed of the mouthpiece) the technique of subtone is often used and requires a very specific embouchure. Weiss & Netti describe subtone as a sound which is weak in overtones used to play softly in the lower registers. They describe two methods of execution:

> 1) Tongue on the reed: Here: the front part of the tongue or the tip or the tip of the tongue is pressed against the reed. In doing so, the reed is muted and the subtone is created. For this purpose, the lower lip must be turned a bit outward. At the same time, the embouchure is very loose which also explains why a transition to normal playing requires an adjustment... Air sounds cannot always be completely excluded.
> 2) Little mouthpiece and loose embouchure: On the higher pitched saxophones, in particular, it is easier to shorten the embouchure. This means that the lower lip almost touches the edge of the reed, very little mouthpiece is in the mouth and the embouchure is very loose. In this way the reed is dampened and not fixed between the upper teeth and the lower lip as in the normal embouchure... Here, too, the transition from the subtone embouchure technique to normal embouchure cannot always be executed smoothly.
> (Weiss & Netti 2010 p. 162).

Big band jazz players have been using this technique since the thirties and it is a part of conventional jazz technique but the classical world makes a clear distinction between a normal and a subtone. Figure 1.28 shows a use of the technique from Mark-Anthony Turnage's *Two Elegies Framing a Shout* (1997) where the composer makes the clear distinction between the passage that is to be played subtone and the passage that is to be played ordinarily. Tanada's *Mysterious Morning III* (1996) employs subtone as a way of exaggerating the extreme use of dynamic and timbre change (figure 1.29).

Fig.1.28 Mark-Anthony Turnage *Two Elegies Framing a Shout* (1997) movement 1 b.29

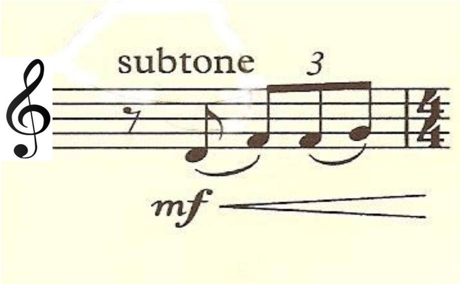


Fig.1.29 Fuminori Tanada *Mysterious Morning III* (1996) p.7 line 5

Key Percussion

The technique of key percussion is particularly effective on the saxophone as the large key cups (required because of the saxophone's conical shape) allow a particularly resonant sound; indeed, Weiss & Netti add that 'already during normal saxophone playing, key sounds are often (too) clearly audible' (Weiss & Netti 2011 p.176). There are two types of sound when using key percussion: a dryer sound involving slapping the keys whilst the instrument is out of the mouth, and a more resonant 'popping' sound with the instrument in the mouth. Weiss & Netti also note that 'for key slaps with a closed embouchure, close the mouthpiece with the tongue; this reinforces the resonance' (Weiss & Netti, 2011 p.177). This phenomena is used to effect in Pedro Itturalde's piece *Pequena Czarda* (1997) during which the composer asks the saxophonist to keep the instrument out of the mouth whilst performing the key percussion. This produces a sound which is pitched a minor third higher than the note which is operated due to the lack of the standing wave in the instrument (standing waves are explained in chapter 2, section 1). Figure 1.30 shows the application of this in the score: the lower notes being played and the higher notes being sounded. I have recorded the phrase shown in figure 1.30 (track 27) with the saxophone both held outside and inside the mouth to highlight the change of sound. Key percussion is normally used as a specific timbre as in Jindrich Feld's sonata (1989-1990, figure 1.31) where the saxophone's key clicks are played alternately with tapping sounds

Fig.1.30 Pedro Itturalde *Pequena Czarda* (1997) p.3 lines 7 and 8

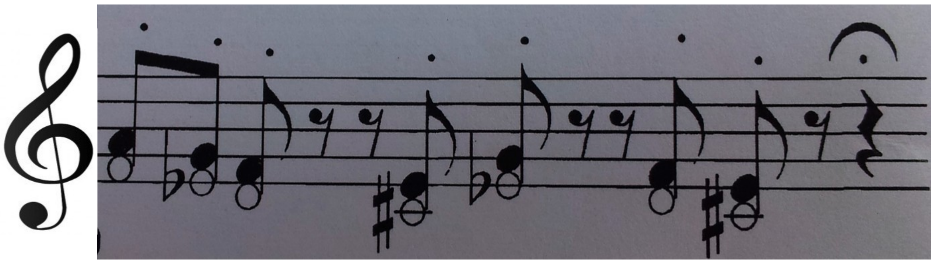
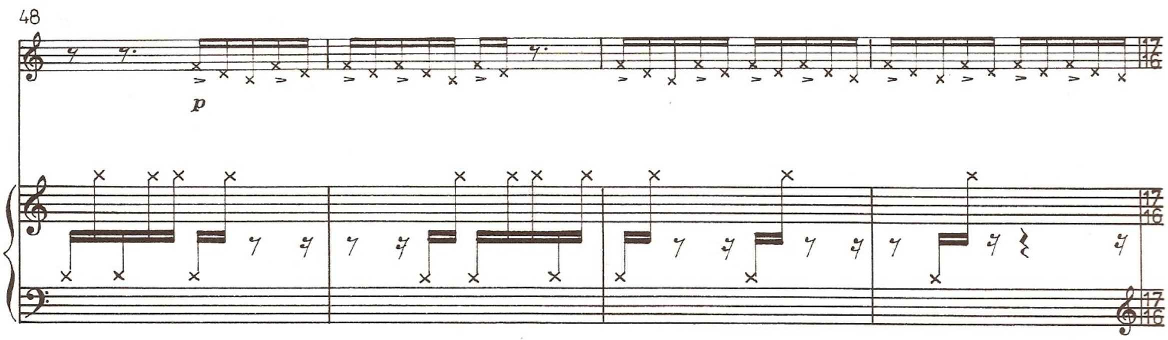
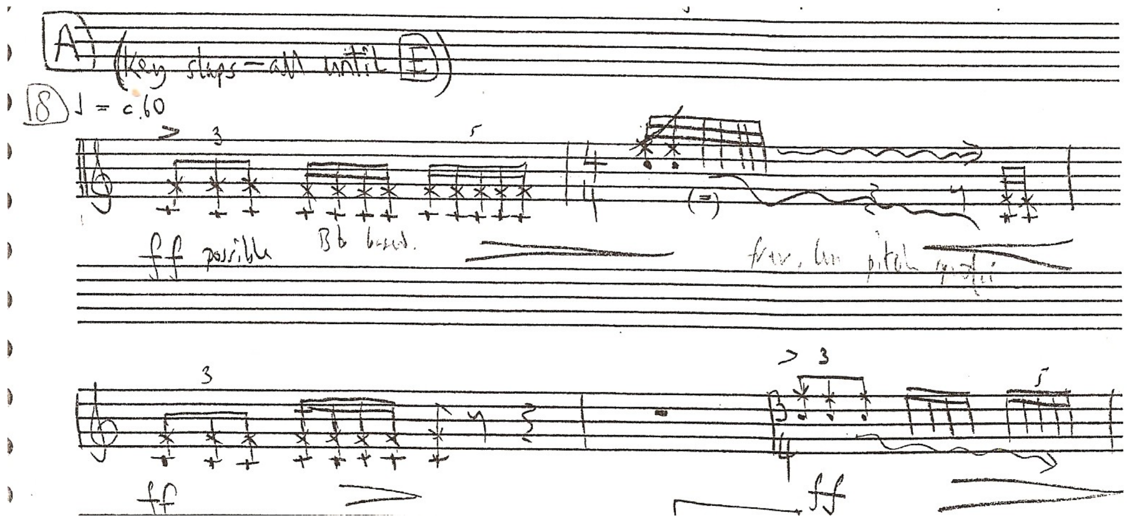


Fig.1.31 Jindrich Feld Sonata For Alto Saxophone and Piano (1989-1990) Mvmt II bb.48-51



from the piano to create a timbral duet between the two instruments. Key percussion also has a place in electronic music as the percussive nature of the technique can be specifically manipulated by a max/msp patch or similar computer programme. In Michael Clarke's *Enmeshed* (2005) the tenor saxophone feeds the patch rhythmically-specific key slaps for an entire section of the piece, the timbre of which punctuates the rest of the work as the computer manipulates and then recycles the material (Figure 1.32).

Fig.1.32 Michael Clarke *Enmeshed* (2005) figure A

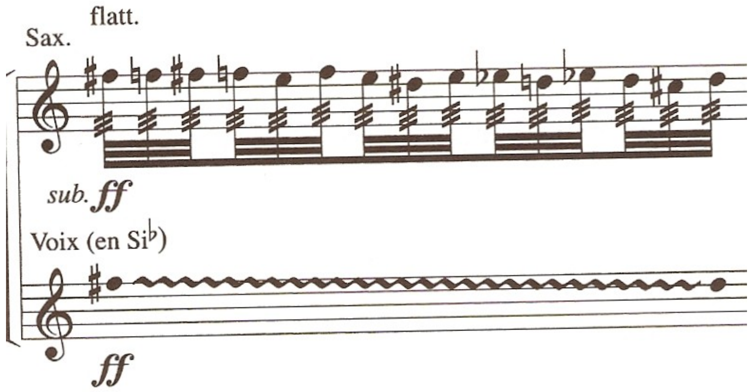


Flutter Tongue

Flutter tonguing is designed to disrupt the air stream of a pitch adding a rhythmic disturbance to the sound. There are two ways of producing this effect: the first is by rolling a Spanish 'rrr' with the tip of the tongue against the soft pallet, and the second is by vibrating the soft palate against the back of the throat. Some people find it difficult, or even impossible, to produce the effect with the tongue and so must rely on the second method of production which produces a slightly less defined sound than the first method. An early use of flutter tongue can be found in Denisov's Sonata for Alto Saxophone and Piano (1973) where the composer uses it to emphasise the saxophone's line especially low down in its register (figure 1.33).

Fig.1.33 Edison Denisov Sonata for Alto Saxophone and Piano (1973) movement III bb.69-70

Fig.1.34 Fuminori Tanada *Mysterious Morning III* (1996) p.3 line 1



Tanada uses the effect in his composition *Mysterious Morning III* (1996) to transform and distort an already familiar phrase; resulting in a different timbre as depicted in figure 1.34. Composers are beginning to understand the difference between the two methods of production, and Aaron Cassidy's work *Asphyxia* (2000) makes use of both types independently of each other through use of specific notations for each (figure 1.35).

Fig.1.35(a) Aaron Cassidy *Asphyxia* (2000) b.26

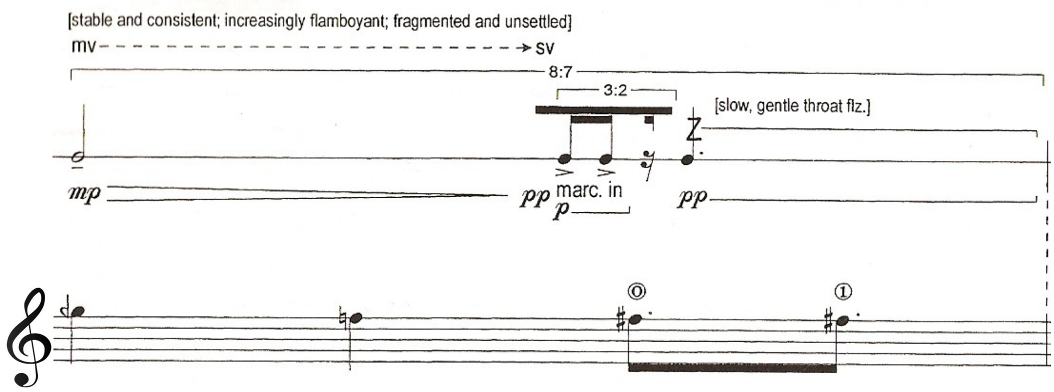
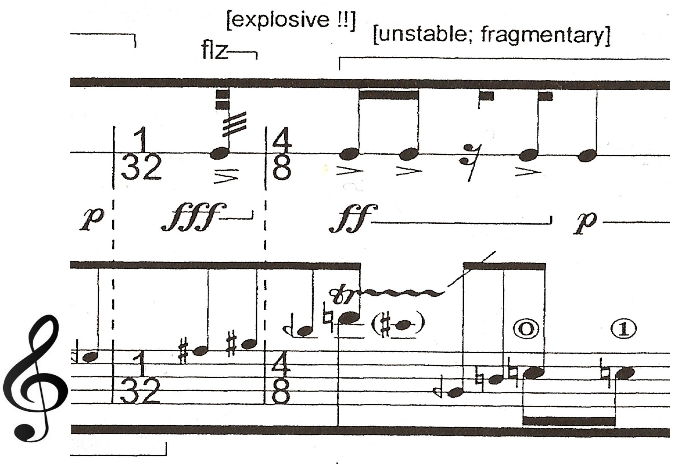


Fig 1.35(b) Aaron Cassidy *Asphyxia* (2000) b.30

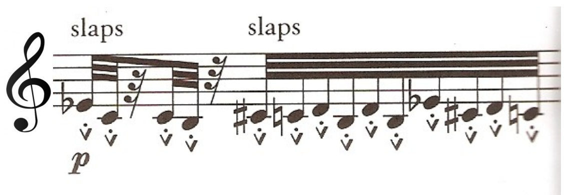


Duration Techniques

Slap Tongue (Short)

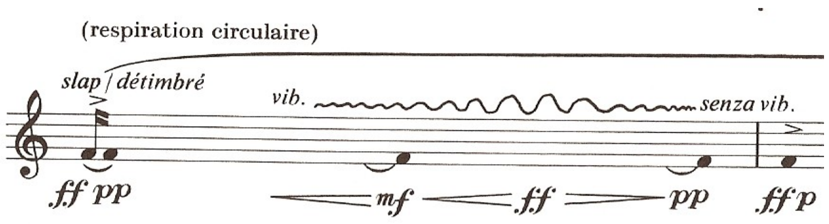
This is a technique which uses the tongue to pull the reed abruptly away from the mouthpiece to create a percussive sound as the reed hits the rails of the mouthpiece when returning to its original position. The saxophonist does this by laying the tongue flat against the reed and then curling it so that it is concave against the reed. This causes a small vacuum between the reed and the tongue so when the tongue is pulled away the reed follows it until the vacuum is broken. The elastic properties of the reed cause the reed to snap back and thus create the 'slap'. Depending on the amount of air that is passed over the reed at the same time, the slap tongue effect can be used either to punctuate short percussive passages as in Christian Lauba's *Jungle* (1996, figure 1.36) or to begin a note

Fig.1.36 Christian Lauba *Jungle* (1996) p.14 line 8



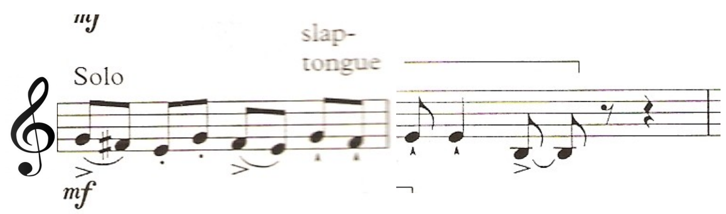
with a percussive accent as in Betsy Jolas' *Épisode Quatrième* (1983, figure 1.37). Slap tongue can also be used as a melodic device acting as an exaggerated articulation to normal tones. This use of the technique is reminiscent of music-hall usage of the technique and can

Fig.1.37 Betsy Jolas *Épisode Quatrième* (1983) b.1



be found in the movement *Old Sir Faulk* from William Walton's *Façade* (1936, figure 1.38). Weiss & Netti characterise the slap in three ways: a standard slap which is pitched; a secco slap that is un-pitched (without air); and an open slap where the embouchure is opened alongside the tongue attack; Weiss & Netti add the caveat that 'this articulation, too, is only possible as a short sound since, of course, the embouchure is opened' (Weiss & Netti 2010 p.143, track 28).

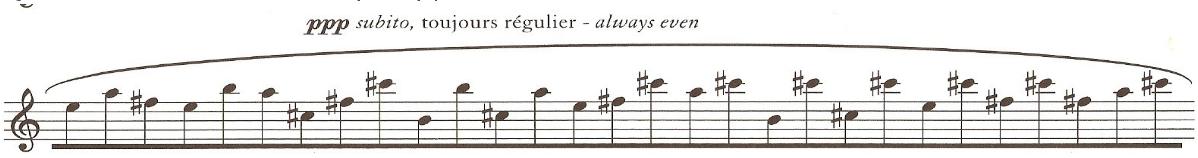
Fig.1.38 William Walton *Old Sir Faulk* from *Façade* (1936) bb.14-15



Circular Breathing (Long)

The method of inhaling whilst expelling air through the instrument is a well known one, and although there seems to be little documentation of its origins it is thought to have developed through folk music. The technique itself involves holding air in the cheeks and using this air to sound a tone whilst breathing in through the nose. The manipulation of the soft palate and uvula to open or close access to the nasal cavity makes this possible, resulting in the ability to play phrases that are much longer in duration than a normal lung-full of air could sustain. In his book *Circular Breathing for Woodwind Players* (1979), Trent Kynaston describes the types of breath players need to develop: 'High breath' involving the top of the lungs and lifting the clavicles (collar bones); 'Middle breath' using the lungs and expending outwards around the area of the rib-cage; 'low breath' which uses the diaphragm and 'total breath' which mixes the previous three methods (Kynaston 1978, pp. 3-5). As speed is a factor in circular breathing, it is recommended by Kynaston that the 'low breath' technique is used so as to maximise the intake of air in the shortest amount of time possible. Circular breathing can be found in a number of saxophone compositions, for example Lauba's *Balafon* (1996) includes a constant stream of quavers which demands an un-broken supply of air (figure 1.39). The technique of circular breathing is particularly widely employed in improvised music, with saxophonists such as Evan Parker, Frank Gratkowski and John Butcher using the technique extensively for solo playing.

Fig.1.39 Christian Lauba *Balafon* (1996) p.1 line 8



The techniques that are described here are the most common techniques which appear in the saxophone's repertoire; other techniques such as: whistle sounds (extremely high tones produced by constricting the reed with the embouchure, or placing the teeth on the reed); unusual tongue articulations (tongue side to side or up and down); ram-tongue with the reed in place; and trumpet sounds into the crook, have their place in improvised music but have yet to become established in widely available notated repertoire. Each of these techniques requires a specific physical manipulation for their production, using the tongue, lips, embouchure, fingering combinations and diaphragm control. Unlike standard woodwind instrumental technique these parts of the body play a much larger role in the production of extended techniques. In order to produce an extended technique in this way, the performer needs to understand how the techniques work acoustically, and thus be able to manipulate them successfully through use of their physiology.

Chapter 2

The Acoustical Behaviour of Woodwind Instruments: An Overview

When considering an approach to interpreting extended techniques in the saxophone's repertoire, an understanding of the science behind these techniques is useful in helping the performer produce the techniques accurately and manipulate them in such a way as the score might demand. Many performers mention the 'feel' of a technique especially in improvised music; performers such as John Butcher and Frank Gratkowski organise their material in various ways depending upon the demands of the technique and the direction of the music. John Butcher uses fingerings to move from one multiphonic to the other, and similarly Gratkowski groups multiphonics together in order to travel efficiently between the fingerings. In the case of written music, however, a performer is often faced with a technique with which they are unfamiliar and therefore it is often necessary to learn the technique from scratch; Rob Buckland acknowledges the importance of tongue position when performing and preparing extended techniques whilst asserting that composers are largely unaware of the physiological manipulations needed for such playing.

There are concepts that can contextualise what is needed in the preparation and execution of these techniques for a performer and these concepts can be represented in two groups: (1) understanding the acoustic phenomena behind the production of the techniques and (2) understanding the physiological changes required by the saxophonist in order to manipulate these techniques as the score requires. These manipulations can be very important to individual performers' interpretations of a passage of music as each performer's physiology is different from the next, giving differing vocal tract resonance, voice pitch and timbre, tongue positioning and fingering choices depending upon the performer.

Part I: Acoustical Properties Common to All Woodwind Instruments

Tubes

When considering extended techniques on the saxophone it is worth noting that although the instrument acts in a similar way to other woodwind instruments when playing throughout its normal compass, when performing extended techniques a different mode of acoustical phenomena is utilised. This means that although the clarinet and the saxophone are similar in that they are single reed woodwind instruments, other factors affect this acoustic phenomena which, in turn, affects the sounds that can be achieved. All woodwind instruments fall into three categories: cylindrical tubes which are open at both ends (flute, piccolo); cylindrical tubes which are closed at one end (Clarinet); and conical tubes that are closed at one end (saxophone, oboe, bassoon). Bruno Bartolozzi (1982) outlines the behaviour of woodwind instruments as 'the only ones which use a 'mixed' system of sound production (i.e. fundamental tones for the lower register and various natural harmonics for the upper registers)' (Bartolozzi, 1982 p.12). The woodwinds have the capability of producing at least one entire octave of fundamental tones before it is necessary to use the harmonic series, thus creating a 'mix' of fundamental and harmonic tones spanning their entire compass. Bartolozzi continues by saying woodwind instruments therefore face the 'impossibility, with this traditional 'mixed' system of sound production, of obtaining any sounds other than the fundamentals determined by the construction of the instrument and their related harmonics' (Bartolozzi, 1982 p.12). Bartolozzi is making the observation here that the construction of the instrument dictates the overall behaviour of the harmonics, and this is relevant when considering extended techniques because the performer's choice of mouthpiece, reed and instrument will have some effect on the harmonics produced and thus the extended techniques that are the result of this combination. The amount of choice a saxophonist has in terms of equipment, reeds, ligatures and mouthpieces is significant, and this choice can drastically alter the sounds that result from this choice as will be demonstrated later in this chapter.

Sound Waves From Pipes

The behaviour of the woodwind instrument's fundamental and harmonic tones can be better understood by first examining the acoustical properties of open and closed pipes. The difference between open and closed cylinders is typically exemplified by the flute (open pipe) and clarinet (closed pipe). The flute's exposed embouchure hole makes the flute open to the air at both ends of the instrument, whereas the clarinet mouthpiece results in a closed pipe as the gap between the reed and the lay of the mouthpiece is in the performer's mouth and is therefore pressurised by the player, meaning that it is open to the air at one end of its length only. Chen, Smith and Wolf pose this question in their studies: why does the lowest note of the clarinet sound nearly an octave (major seventh) lower than the flute even though their tube lengths are nearly identical?[1] To explain this one can observe the behaviour of a pulse of air sent down a pipe which is open at both ends, during which the following phenomena occurs:

> [the air] reaches the end of the tube and its momentum carries it out into the open air... it spreads out in all directions [and] its pressure falls very quickly to nearly atmospheric pressure[.] However, it still has the momentum to travel away from the end of the pipe... the result is that a pulse of high pressure air travelling down the tube is reflected as a pulse of low pressure air travelling up the tube.
>
> (Chen, Smith and Wolf, n.d. pp2-3)

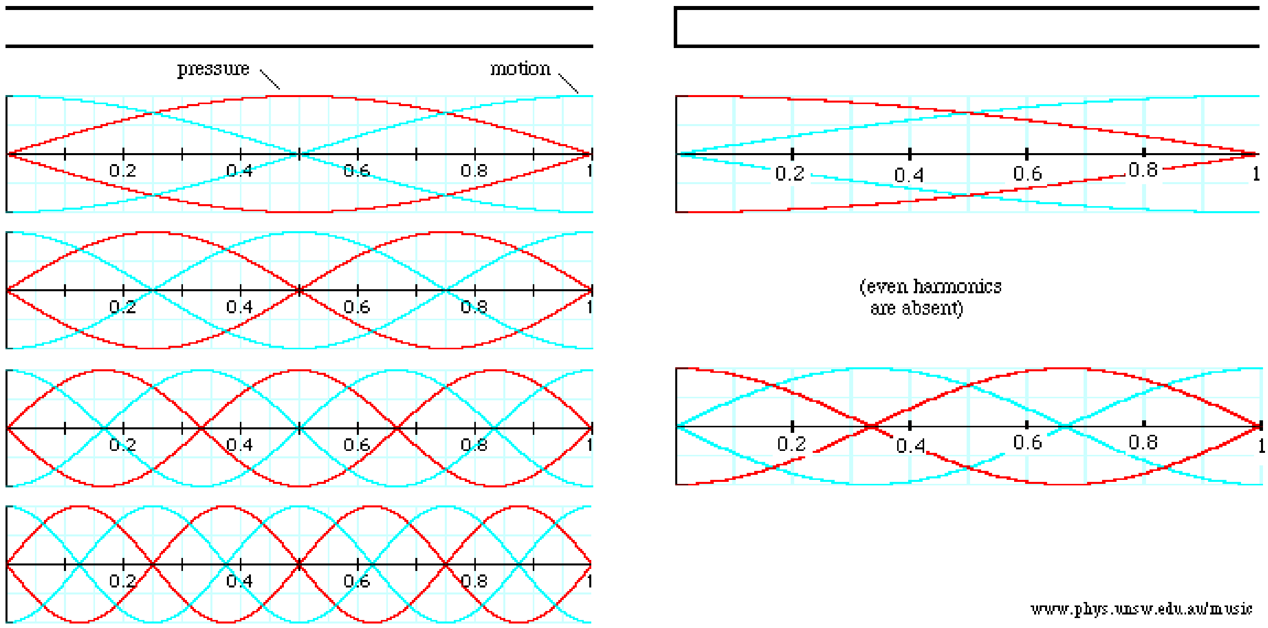
Figure 2.1 is taken from Chen, J, Smith J, Wolfe J, *Open vs. Closed Pipes (Flutes vs. Clarinets)*, in which some generalisations are made regarding the flute. Firstly the length of the flute is estimated to be 0.6m and secondly it is assumed that the speed of sound travels at 340m/s. It is observed that the red wave in figure 2.1 is only half the length of a sine wave, therefore the longest complete sine wave the flute can produce is twice the length of the instrument: approximately 1.2m. The equation needed to find a frequency is therefore (340/1.2= 283.3°) 283.3Hz. This equation gives us a wave that equates to the note C#4 which (given the number of variables and generalisations made) is close enough to the

[1] To illustrate this I have measured my own instruments: flute – 66cm, Clarinet – 67cm. Both measurements were taken with the head-joint/mouthpiece pushed all the way in.

actual note C4 which is the lowest note of the flute. The authors have then included in their diagram other wavelengths that can fit inside the first:

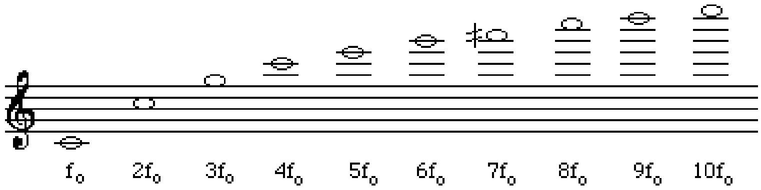
> Note that we can also fit in waves that equal the length of the flute (half the fundamental wavelength so twice the frequency of the fundamental), 2/3 the length of the flute (one third the fundamental wavelength so three times the frequency of the fundamental), 1/2 the length of the flute (one quarter the wavelength so four times the frequency of the fundamental). This set of frequencies is the (complete) harmonic series
>
> (Chen, Smith and Wolf, n.d. p.2)

Fig.2.1 Diagram of wavelength behaviour in both an open pipe (left, representing the flute) and a closed pipe (right, representing the clarinet) whilst performing the harmonic series



This gives us the frequencies 566.6Hz (C#5), 850Hz (G#5) and1133.2Hz (C#6) which corresponds to the natural harmonic series which is displayed in figure 2.2 as displayed in Chen, Smith and Wolfe. It should be noted that due to the amount of mathematical variables mentioned earlier these calculations are nearly a semi-tone sharp from the flute's actual sounding pitches; however, the equations give performers an understanding of the theory behind the tube's acoustical behaviour. The harmonic series can be represented as a multiple of the fundamental frequency; therefore two times the fundamental frequency is the second partial, three times the

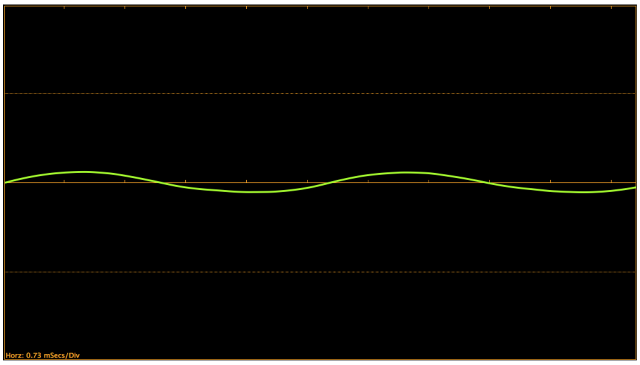
Fig.2.2 The natural harmonic series taken from Wolfe, J. (n.d.). *Open vs Closed Pipes (Flutes vs clarinets)* available at: www.phys.unsw.edu.au/jw/flutes.v.clrinets.html.



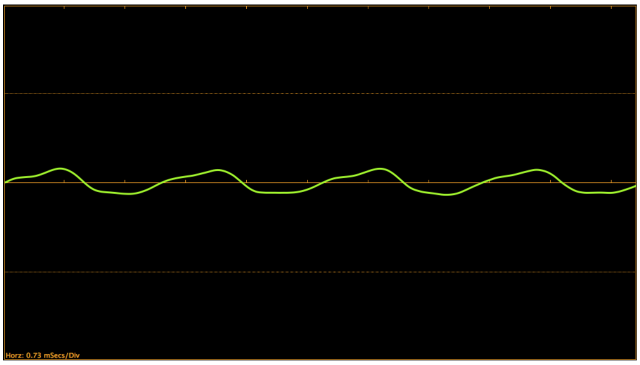
fundamental is the third partial, and so on. To demonstrate this the following diagram is an oscilloscope reading of the author playing the fundamental and first three partials of the flute (track 29). Notice how the wavelengths do indeed double following the ratios described above:

Fig.2.3 Oscilloscope reading of the author playing the fundamental (C4) and first three partials (C5, G5, C6) on the flute, with the corresponding ratios where λ = wavelength

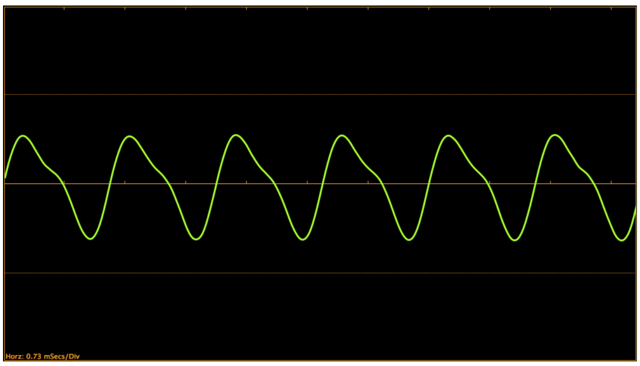
f (λ/1)



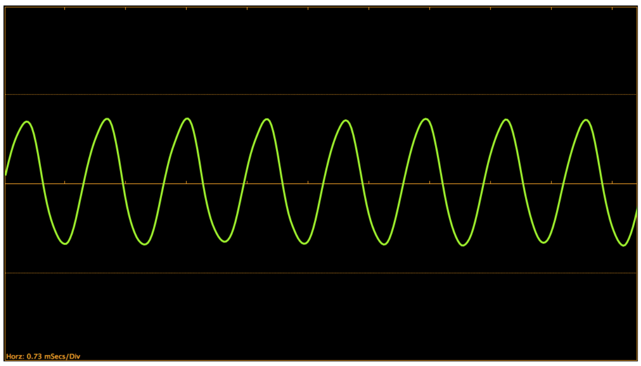
2f (λ/2)



3f (λ/3)



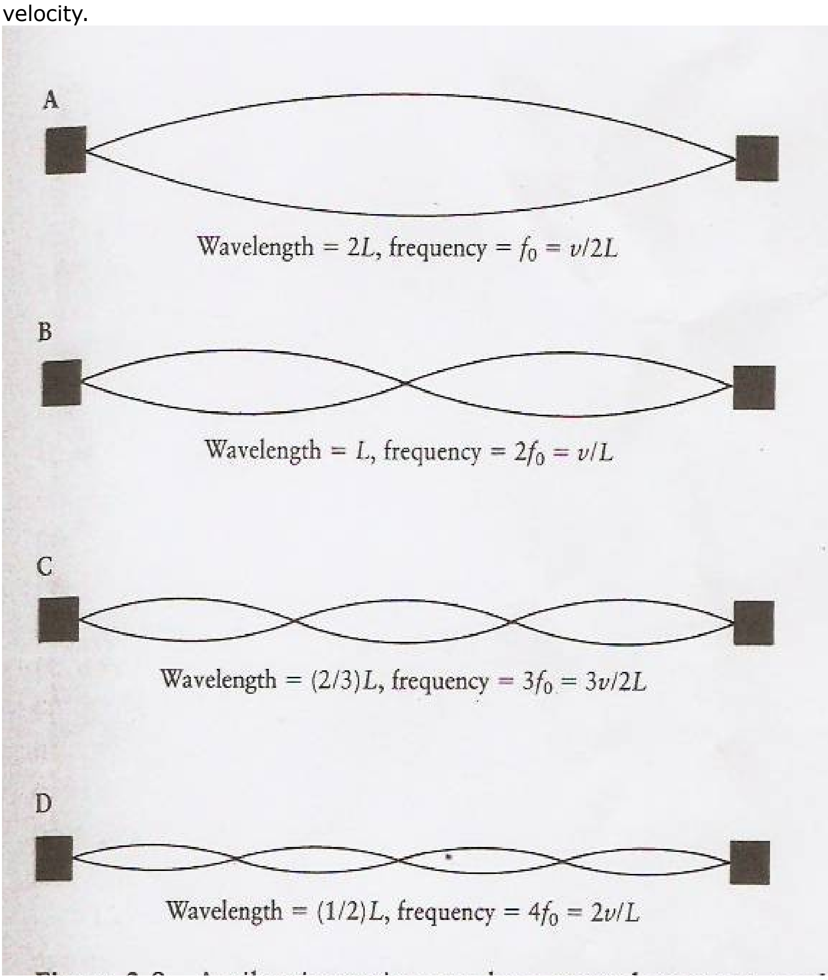
4f (λ/4)



When the above diagram is compared with the vibrations of a string the same effect can be seen, and similar mathematics as outlined in this diagram from *The Science of Musical*

Sound by John R. Pierce (1983). The fundamental here is also twice the length of the string in order to make a complete sine wave, hence doubling the length of the string in order to find the fundamental pitch (2L) as we did with the example of the flute.

Fig.2.4 Ratios of a vibrating string where L = Length (of resonator), f = frequency and v = constant velocity.



These generalisations and assumptions seem often to be used when referring to the study of actual musical sound as defended by John R. Pierce in his book T*he Science of Musical Sound*:

> In practice, we use the *ideas* of sine waves and their frequencies and amplitudes to characterise the musical sounds, and other sounds as well. The measurements we really make are those suitable for our purposes, and are as accurate as they need be.
>
> (J.R. Pierce, 1983 p.44)

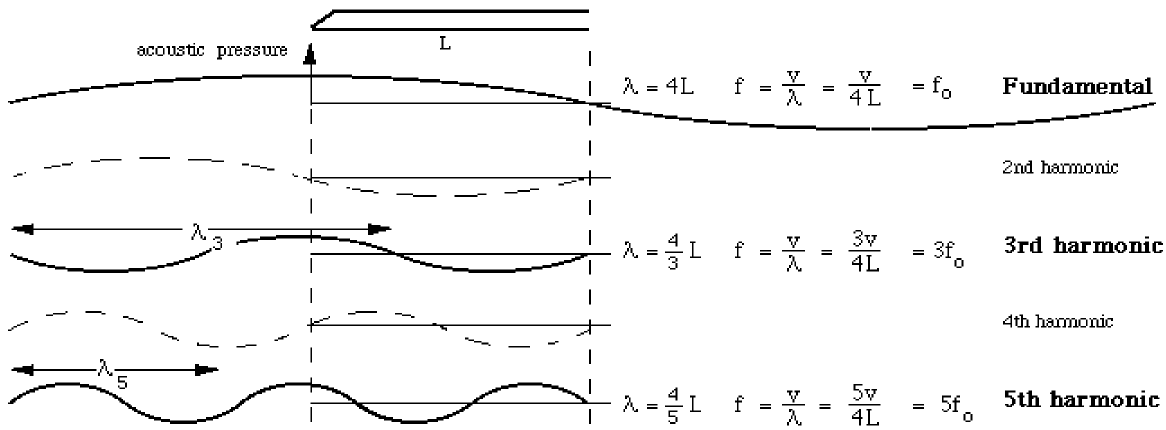
In order to gain a practicable understanding of acoustical physics such mathematical variables and discrepancies that may be present can be discounted so that a musician can rely on useful approximations to build a picture of how musical sounds work.

Standing Waves in Pipes

Chen et al stated earlier that when the sound-waves of the flute, which has an open pipe, reaches the end of the tube 'it spreads out in all directions [and] its pressure falls very quickly to nearly atmospheric pressure'. When one end of the tube is closed, however, a different resulting wavelength is produced and therefore a different harmonic series .This fact is in sympathy with the impossibility of 'obtaining any sounds other than the fundamentals determined by the construction of the instrument, and their related harmonics as stated earlier by Bartolozzi (1982). Figure 2.5 shows how the wavelength for an instrument with a pipe which is closed at one end is significantly longer than that of an instrument with a pipe which is open at one end. This is due to the high pressure pulse being reflected back up the tube as a second high pressure pulse as it reflects off the atmospheric pressure which is called a standing wave (Chen, J, Smith J, Wolfe J, *Open vs. Closed Pipes (Flutes vs. Clarinets)* n.d. p.3) producing only one quarter of a sine wave and therefore the note produced equates to a wave that is four times the length of the tube (0.6m times 4 = 2.4m). Using the same equation as before to find the frequency of this wavelength we find that speed divided by wavelength (340/2.4) gives us the frequency 141.6Hz resulting in the note C#3. The lowest note on the clarinet is D3 and so this time the result of this equation is a semi-tone flat again due to the amount of variables that have not been taken into account for this study.

Figure 2.5 which is taken from Chen, J, Smith J, Wolfe J *Clarinet Acoustics: An Introduction* demonstrates the harmonic series of the clarinet, where the wavelength is equal to the four times the length of the tube (l), and constant velocity (v) divided by the wavelength (λ) gives us the frequency (f). In figure 2.5 the second and fourth partial are only theoretical

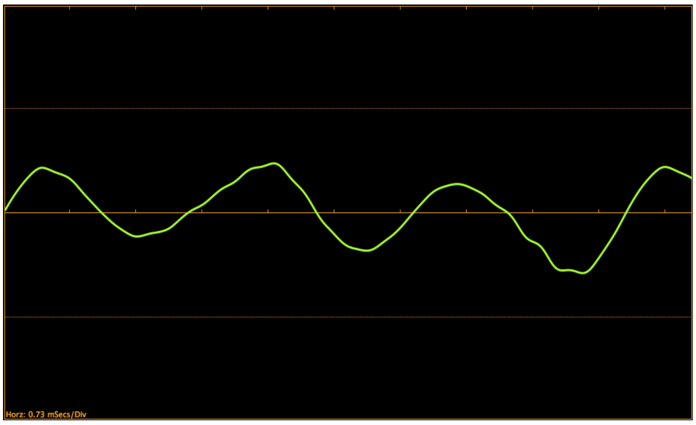
Fig.2.5 Wavelengths within a cylinder closed at one end



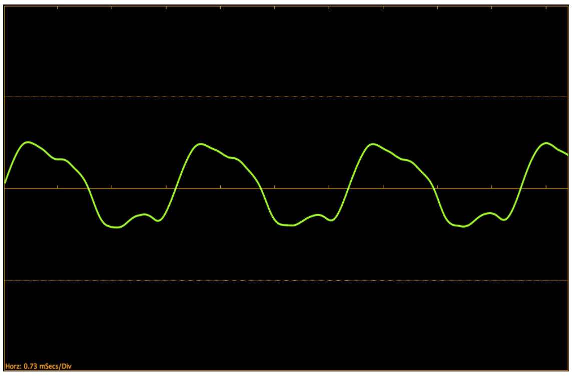
on the clarinet and they equate to the wavelength pattern of the first and second partial of the flute. The wavelength is always partially within the tube-length, this is due to the acoustic impedance of the high pressure wave reflection produced by the closed tube. The practical upshot of this is that the clarinet can only produce the odd numbered partials of the harmonic series, which I have once again demonstrated by recording myself playing the fundamental and first two partials on my own instrument (figure 2.6, track 30). The clarinet's behaviour is different to that of the flute as the wavelength is not neatly doubling but fits only within fractions of itself. These uneven ratios mean that not every partial is possible, indeed the octave (for example) would be double the frequency therefore double the wavelength yet a double wavelength does not appear in practice. The inability to produce all of the notes in a harmonic series impacts on the type of harmonics and therefore multiphonics the instrument can play, and therefore limiting the type of extended technique which is available to that instrument.

Fig.2.6 Oscilloscope reading of the author playing the fundamental (D3) and first two partials (A4, F5) on the clarinet, with the corresponding ratios where λ = wavelength

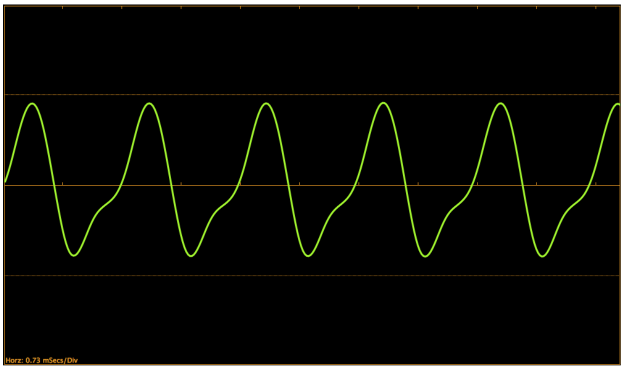
λ=4L



λ=4/3 L



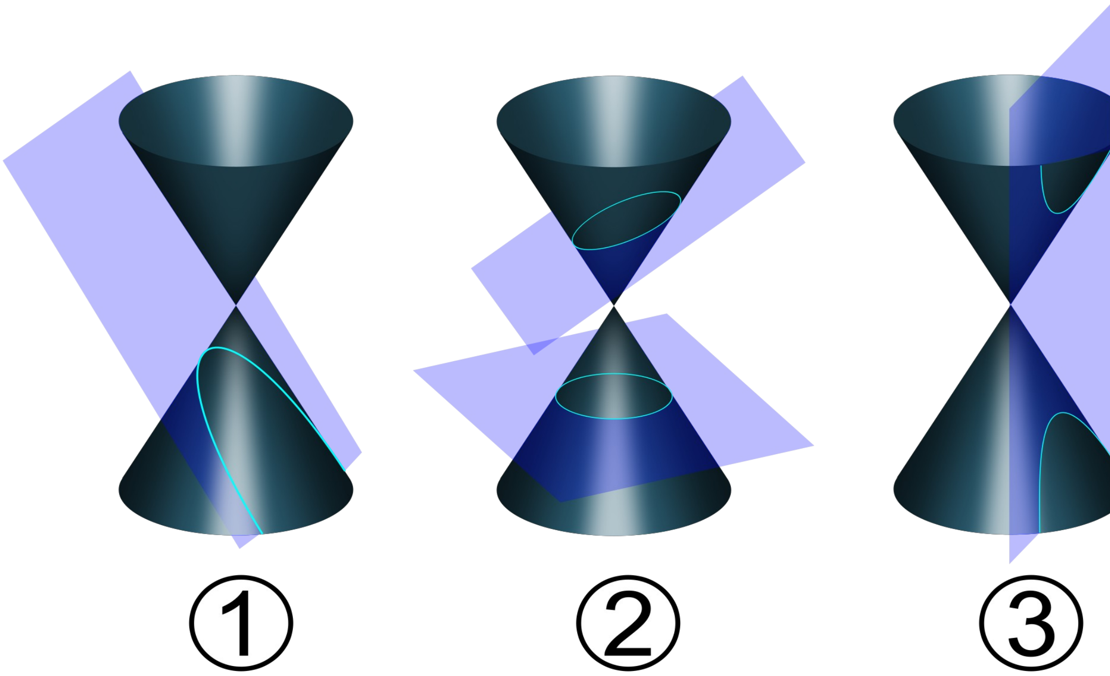
λ=4/5 L



Bore Shape

The specific acoustical behaviour of the saxophone is closely related to the closed pipe and high impedance model seen in the case of the clarinet; however, the bore shape being conical has a further impact on the instrument's harmonic series. The saxophone's bore follows the shape of a 'parabolic curve' (Kool, J. 1953 p.82) as illustrated in figure 2.7. The three types of curve obtained by intersecting cones with a plane are called conic sections and there are three types 1: parabola, 2: circle and eclipse and 3: hyperbola, and the curve of the saxophone according to Sax's original patent is closest to that of a parabola. The conical nature of the saxophone's bore is relevant because it means that a second force is acting upon the wave travelling down the tube as the wave is not only travelling in a linear direction but also in a radial direction. This means that the sound is beginning to spread throughout the bore in a spherical symmetry represented by the

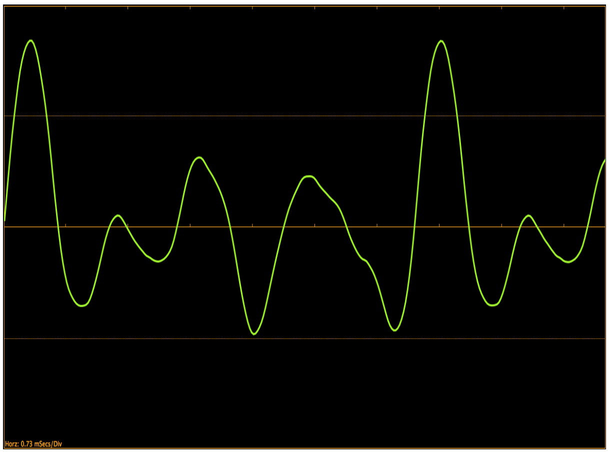
Fig.2.7 Diagram of different conic sections available at
http://en.wikipedia.org/wiki/File:Conic_sections_with_plane.svg



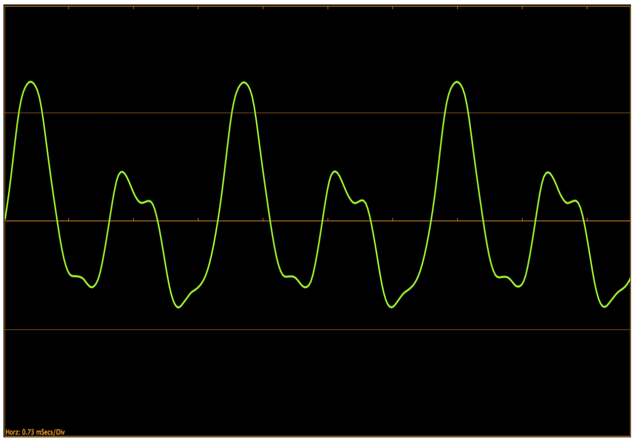
equation $1/r^2$ 'where *r* is the radius of the sphere because it is spread out through the area of a sphere which is proportional to r^2 ...double the distance away, the sound power is spread over four times the area' (Wolfe, J. *Pipes and Harmonics* n.d. p.5). This equation adds an extra factor to the $\lambda=4L$ equation used for the clarinet and therefore it changes the behaviour of the instrument, Wolfe states that 'the standing wave in pressure has an envelope which is ($1/r$) times a sine wave with a wavelength which is 2L/n, where L is the length of the instrument and n is an integer' (Wolfe, J. *Pipes and Harmonics* n.d. p.5). Figure 2.8 (track 31) shows the third set of results collected by the author this time playing the fundamental and the first three partials on a soprano saxophone. Here the ratio of partials in relation to the fundamental is the same as the flute in that the frequency is relative to the proportion of the wavelength. The radial effect of the bore is significant as it allows the saxophone, via means of its conical shape, to play all of the partials in the harmonic series even though it is a closed tube with high atmospheric pressure at the top and low pressure at the bell like the clarinet.

Fig.2.8 Oscilloscope reading of the author playing the fundamental (A3) and first three partials (A4, E5, A6) on the soprano saxophone, with the corresponding ratios where λ = wavelength

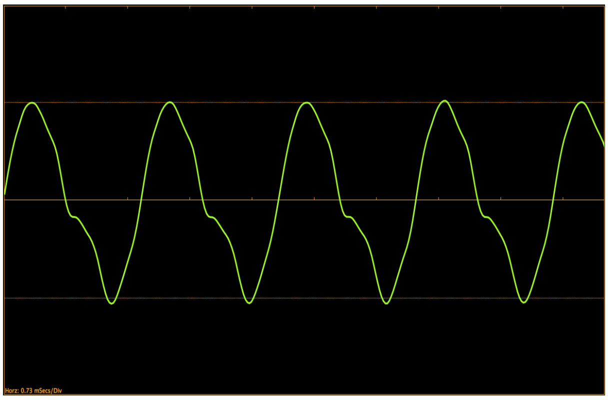
f (λ/1)



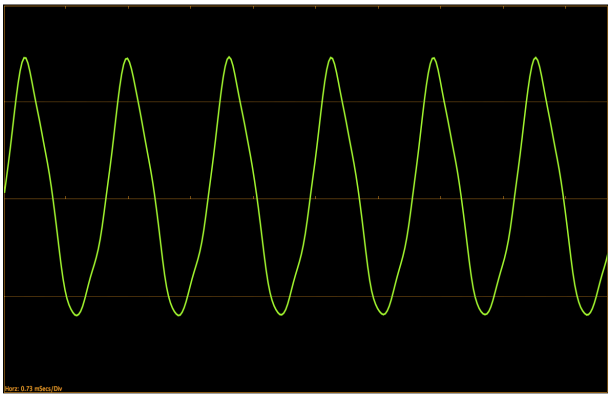
2f (λ/2)



3f (λ/3)



4f (λ/4)



The acoustical behaviour of the saxophone's closed pipe design - as opposed to the clarinet's or the flute's design - account for the techniques it can produce using the harmonic spectrum. When comparing the saxophone's multiphonic types to the clarinet's multiphonic types it is clear that there are many more strongly oscillating multiphonic sounds involving intervals such as minor ninths and minor twelfths as opposed to the clarinet's wider multiphonics with less oscillation.

Impedance (z)

An understanding of acoustic impedance helps the performer to appreciate how the different dimensions of their specific choice of instrument dictates the sound that will result not only in extended technique playing but also in their overall sound and harmonic series. Pressure acting upon a wave from the atmosphere is significant to the acoustical properties of that wave, this is referred to as acoustic impedance (z) which is a force that is a result of the medium through which the wave travels, as outlined by Joe Wolfe: 'acoustic impedance has the advantage of being a physical property of the instrument alone – it can be measured (or calculated) for the instrument without a player. It is a spectrum, because it has different values for different frequencies – one can think of it as the acoustical response of the instrument for all possible frequencies' (Wolfe, J. *What is Acoustic Impendance and Why is it Important?* n.d.). This idea of a measurement which is taken from a medium independent of any external factors is also stated in Arthur H. Benade's book *Fundamentals of Musical Acoustics* as follows: 'The wave impedance... is a way of specifying (along with the wave velocity) one of the attributes of the wave carrying medium itself, without reference to its boundaries. As a matter of fact, one of the easiest ways to measure a wave impedance is to experiment on a very extended piece of material and to conclude the measurements before any echoes can be returned by its boundaries' (Benade, 1976 p.330). This has significance to a performer's choice of instrument as each saxophone has slightly different bore dimensions, thickness, material and brass composition, especially the popular handmade Selmer Paris instruments of the pre 1970s. All of these variables have some effect on the impedance produced in the instrument and therefore the response and behaviour of extended techniques that can be performed.

Fig.2.9 Acoustic impedance of a theoretical cylinder which is effectively infinite in length and has no external factors acting upon taken from Wolfe's article *Pipes and Harmonics*

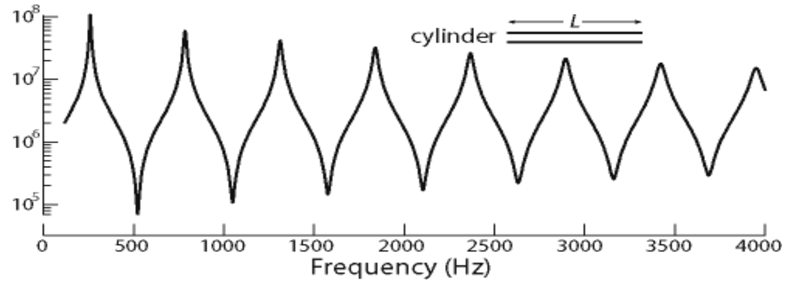
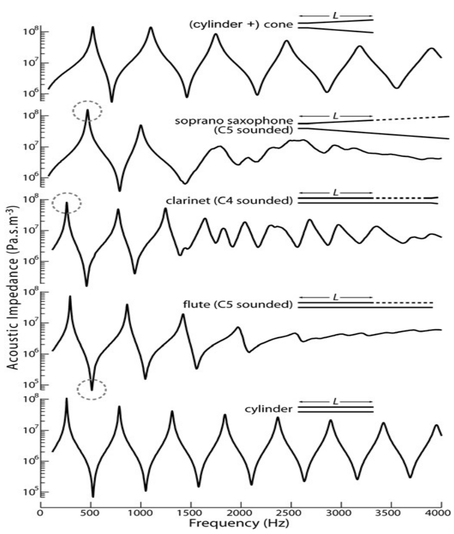


Figure 2.9 shows the acoustic impedance of a theoretical cylinder which is effectively infinite in length and has no external factors acting upon it which, according to Wolfe, is a system regularly employed to measure the characteristics of acoustical impedance. The measurement on the *y* axis of the graph measures the acoustic impedance of increasing frequencies on the *x* axis and it is clear that the impedance decreases slightly the higher in frequency the instrument plays. The unit of measurement for musical impedance is quite a complex one:

> The unit of pressure is the Pascal – one Newton per square metre. A Pascal is a big unit for sound: an oscillation of one Pa is usually a very loud sound indeed... Flow is measured in cubic metres per second. (A very gentle breeze coming in your window could be 1 m3/s. But for 1 m3/s to flow down a pipe, either the pipe must be big – think ventilation ducts – or the speed must be high.) The units for impedance are therefore Pa.s/m3, which we call the acoustic ohm Ω. For musical instruments, it is a rather small unit, so we use megohms: MPa.s/m3. Finally, sound pressures have a large range. For this and other, psychophysical reasons we use logarithmic scales for sound level and impedance
>
> (Wolfe, n.d.)

Figure 2.9 shows an inverse proportionality between frequency and the acoustic ohm: lower sounds have a greater impedance than higher sounds.

Fig.2.10 acoustic impedance as measured in a cylinder plus cone, a soprano saxophone, a clarinet, a flute, and a theoretically infinite cylinder



This information becomes more useful for an instrumentalist when applied to their own instrument and so figure 2.10 taken from Chen, Smith and Wolfe's article *Saxophone*

Acoustics: Introducing a Compendium of Impedance and Sound Spectra shows the behaviour of the impedance wave in instrument bores as compared to a cone and cylinder. It is clear from the graphical representation shown in figure 2.10 that in all cases the higher frequencies result in a levelling out of the impedance wave leaving little difference between the previously defined maxima and minima peaks. Wolfe explains that this behaviour is to be expected in musical instruments by observing that 'The acoustic impedance of musical wind instruments varies spectacularly with frequency because these instruments are designed to produce one or several frequencies only in a particular configuration' (Wolfe, n.d.). Wolfe goes on to describe these variances by making reference to the individual instruments' behaviour as discussed previously:

> the flute is played with the embouchure hole (at least partly) open to the atmosphere, so the pressure at the embouchure hole is very near to atmospheric pressure. Thus the acoustic pressure (the varying part) is nearly zero. The flow is provided by a jet of air from between the player's lips. Oscillations of air flow in the flute can cause this jet to deflect upwards (outside the flute) or downwards (inside) so that the acoustic flow... can be large. Thus the flute operates at minima of Z: a small pressure and a large flow. Most other wind instruments have a reed which is sealed by the player's mouth and they operate at maxima of Z: the varying part of the pressure is large, but the oscillating part of the air flow is small at the reed... In each of the impedance curves for the flute, there are at least a few rather deep, sharp minima, and the flute will usually play a note with a frequency near each of those deep minima. The ease of playing and the stability of the note depend on the depth and narrowness of the minima.
>
> Conversely, in each of the impedance curves for the clarinet, there are at least a few rather high, sharp maxima, and the clarinet will usually play a note with a frequency near each of those high maxima. The ease of playing and the stability of the note depend on the height and narrowness of the maxima. For instance the very highest notes are hard to play, and you can see on the spectra that at high frequency the maxima and minima are weaker--they "help the player less". There is more to it than this, however. For the instrument to play properly a note with frequency f, it usually needs an extremum at f, and also extrema at 2f, 3f, 4f etc. The reason for this is that the vibration of the air jet or reed and the sound made by the flute are not simple sine waves. Their waves are periodic waves (that is they repeat in time) and they contain a fundamental and a harmonic series. It is important to the performance of wind instruments that the various minima that help produce a particular note are in the harmonic series
>
> (Wolfe, n.d.)

Here Wolfe has made reference to the importance of the harmonic series and to the idea of each high pitch needing an extrema at 2f, 3f, 4f which explains why higher pitches are difficult to play as the margin for error is greatly increased as the wavelengths become shorter and yet, paradoxically maybe, this is why high pitches are so easily manipulated due to the same phenomena. It is significant that when preparing techniques which exploit the fundamental-and-harmonics model of the saxophone, such as playing in the altissimo register, playing harmonics and multiphonics, the instrument itself has an effect on the sound and this effect will inevitably sound slightly different according to the performer's choice of equipment.

Part II: The Science of Extended Techniques

The Mouthpiece and Embouchure

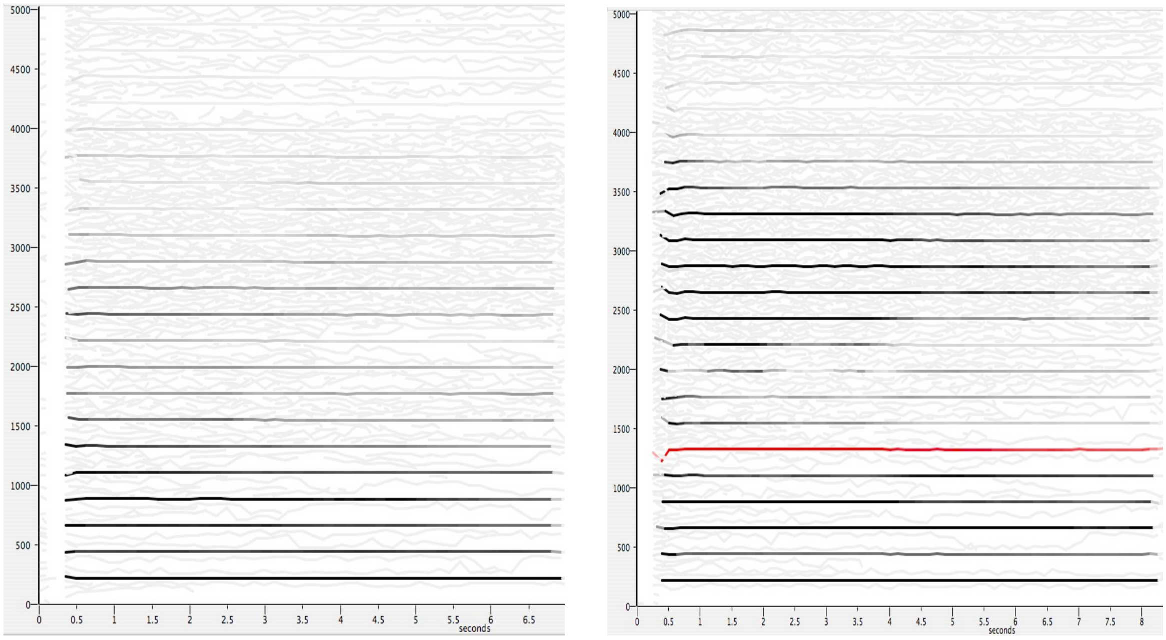
It is common for saxophonists to experiment with the mouthpiece in order to change the overall sound or tone of their instrument; mouthpiece designs are wide ranging and varied with the most common variances being the size of the tip opening (the distance between the tip of the mouthpiece and the reed), the length of the baffle (how much reed is in contact with the flat surface of the mouthpiece) and the shape of the tone chamber. In addition to changing the overall sound it is possible that a change in mouthpiece can also alter the specific partials that appear in a multiphonic, or change the intonation of a quarter tone, and so the performer who wishes to create specific effects according to the score needs to be aware of these differences in order to execute a technique according to their own interpretation.

In F. S. Wyman's study *An Acoustical Study of Alto Saxophone Mouthpiece Chamber Design* (1972) the author states that 'one must keep in mind that there are certain influences on tone quality which are not related directly to mouthpiece design. First and foremost of these is the player's own concept of saxophone tone... The selection of a mouthpiece which has a chamber design which will give a tone quality close to that of the player's 'ideal' is important. Otherwise, the player will have to fight the mouthpiece tendencies by the use of extreme facings, reed contours and the like. Other influences of the player on the tone produced can be traced to differences between individuals in the shape and size of their oral and sinus cavities. Although acoustical studies have shown that oral cavity shape have no effect upon tone quality, many musicians still feel that the oral cavity has much to do with the "centering" of a tone and with making various adjustments in the pitch of a tone. The oral cavity also is an important aid in the damping necessary when playing in the second mode of vibration' (Wyman,1972 pp.61-62). This is a curious statement as surely it can only be the oral cavity that changes an individuals' sound and produces their 'ideal' in the way Wyman suggests, perhaps instead of 'oral cavity' Wyman means 'tongue position' which is usually the main factor in altering the shape of the oral cavity and therefore changes the tone by restricting the air entering the instrument. The conclusion of Wyman's study appears to concur with this as he states the 'control of oral cavity shape allow[s] for difference in tone quality between performers using the same mouthpiece' (Wyman,1972 pp.61-62). Wyman indicates that the 'amount of brightness in the tone is primarily controlled by the baffle shape. A small baffle-to-reed angle tends to promote a bright tone' (Wyman,1972 pp.61-62) which implies that the players' choice of mouthpiece can play a very important role in the development of their sound. Stephen Trier makes the following remark in his article *The Saxophone in the Orchestra*:

> Saxophones are capable of an immense range of dynamics. A large industry has been set up to help the player achieve these extra decibels. It is not possible to produce every type of sound from one mouthpiece and reed... Every kind of material has been used: wood, crystal, ebonite, plastic, and a profusion of metals and alloys. Their object has always been to enable players to produce different qualities and quantities of sound. The saxophones are capable of an enormous variety of timbre, but players need the help of different kinds of reeds and mouthpieces to produce them... One other vital factor in the player-mouthpiece equation is the control of intonation... The player can do a great deal, but it is certain that some mouthpieces do not match every instrument
>
> (S. Trier, 1998).

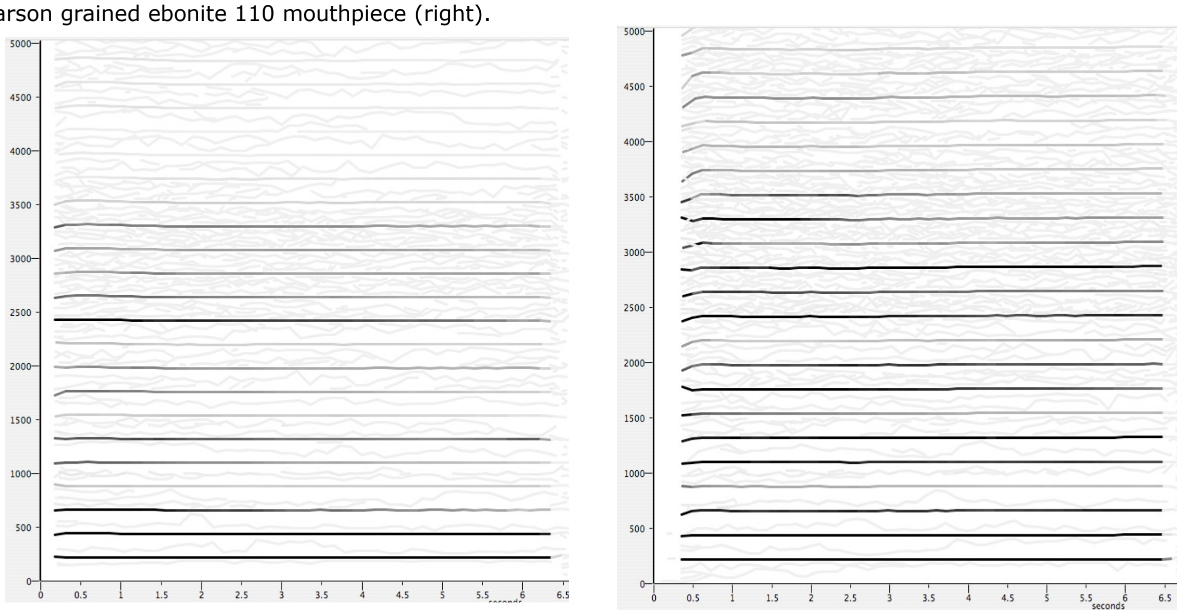
Trier seems to be in agreement with Wyman by concluding that the saxophonist affects the overall tone with their own physiology, yet the mouthpiece choice can greatly help or hinder a player in this task. In order to highlight the connection between mouthpiece choice and overall tone I have have recorded a Concert A4 at 440Hz on both alto and tenor saxophones using a closed, narrow baffled mouthpiece (used for classical playing) and an open, wide baffled mouthpiece (used for pop and jazz playing). In each example the closed mouthpiece appears on the left and the open mouthpiece appears on the right, and the mouthpieces can be heard on tracks 32 (Vandoren) and 33 (Freddie Gregory) of the accompanying CD.

Fig.2.11 A spectral analysis of A4 played on the alto using a Vandoren Optimum AL3 mouthpiece (left) and a Freddie Gregory Model F6 (right).



On the left of Figure 2.11 is a graphical representation of the partials present in the note A4 (440Hz) when played on my Vandoren Optimum AL3 mouthpiece which has a close lay, and on the right is the same note played on my Freddie Gregory Model F6 which has an open lay. In the lower partials not much is different: the fundamental is present as are the partials we would expect to see from the saxophone's harmonic series: 220Hz, 440Hz, 660Hz, 880Hz, 1320Hz etc. It is in the upper partials that the difference can be appreciated as the brighter, wide baffled Freddie Gregory mouthpiece resonates with partials up to 3500Hz; whereas the Vandoren AL3 mouthpiece only has strong partials up to 2650Hz. It is these higher partials that increase the projection and amplitude of the sound making the tone sound 'brighter' and more penetrating. To ensure that it is the mouthpiece only that is changing the sound I repeated the exercise on my tenor saxophone (tracks 34 (Selmer) and 35 (Berg Larson) of the Cd):

Fig.2.12 A spectral analysis of A4 played on the tenor using a Selmer S80 D mouthpiece (left) and a Berg Larson grained ebonite 110 mouthpiece (right).



The partials are all present up to around 3400Hz when played on the Selmer S80 represented in the left hand graph whereas partials are being sounded as high as 4400Hz on the right hand graph which represents the Berg Larson grained ebonite 110 mouthpiece. This explains why saxophonists change their mouthpieces when playing different styles of music as suggested by Stephen Trier and backed up in conversation with Rob Buckland, giving strength to Wyman's claim that 'The selection of a mouthpiece which has a chamber design which will give a tone quality close to that of the player's "ideal" is important giving the saxophonist a choice and overall control over their sound' (1972, pp.61-62).

The tone chamber and lay of a mouthpiece are not the only variables when considering tonal quality in that the reed acts as a valve for the air pressure before the air even enters the mouthpiece itself. Benade summarises the effect of the pressure acting upon the reed in three statements:

1. The resonance frequencies of an air column terminated by a reed are always lowered by a reed's presence, and they are never higher than the natural frequency with which the reed cane itself would vibrate if plucked

like a tuning fork. (Note: this natural frequency is *not* the one obtained by blowing on an oboe or bassoon reed or on a clarinet mouthpiece; in all these cases there is present inside the reed cavity a miniature air column that has significant influence.)

2. Changes in the reed's natural frequency (produced for example by changes in the way in which it is pressed onto the mouthpiece by the player) produce small but parallel changes in the air-column modes that lie far below the reed's natural frequency. These changes become progressively larger for higher modes that lie nearer to the reed frequency.
3. The reed damping produced by the player's lip serves among other things to reduce the magnitude of the changes described in statements 1 and 2, although they are still musically important.

(1972, pp.61-62)

Statement 1 is especially important as it has the most immediate effect; the reed cavity produces a second air column which works upon the bore of the instrument. This explains why the choice of reed in combination with a suitable lay/chamber design affects the sound of the instrument as illustrated above. Benade has also included a diagram of how the flow through the reed-valve system is affected by the pressure across the reed, up to the point the reed closes as shown in figure 2.13. The diagram illustrates a 'sweet spot' where the flow through the reed is facilitated by the pressures of the embouchure acting upon it. This is concurrent with Bernoulli's principle which states that the velocity of a compressible liquid or gas will increase when there is a drop in pressure surrounding it; this principle will be investigated in more detail a little later in this chapter. In the context of saxophone playing the pressure is the highest around the embouchure and low either side of the embouchure thus resulting in a higher velocity as the air passes through the embouchure and into the instrument. A similar graph can be found on the web page *Saxophone Acoustics: An Introduction* by Joe Wolfe where he demonstrates the effect of air flow versus pressure up until the reed closes (figure 2.14, which is very similar to Benade's illustration) and then goes on to show how this effect varies across differing dynamics in figure 2.15.

Fig.2.13 Diagram representing the flow of pressure across a reed.

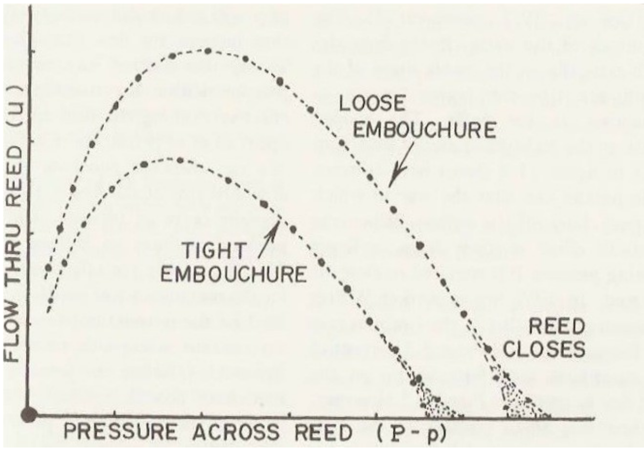
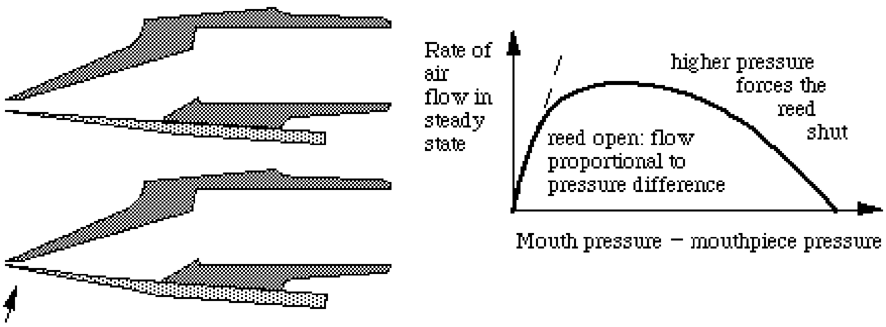
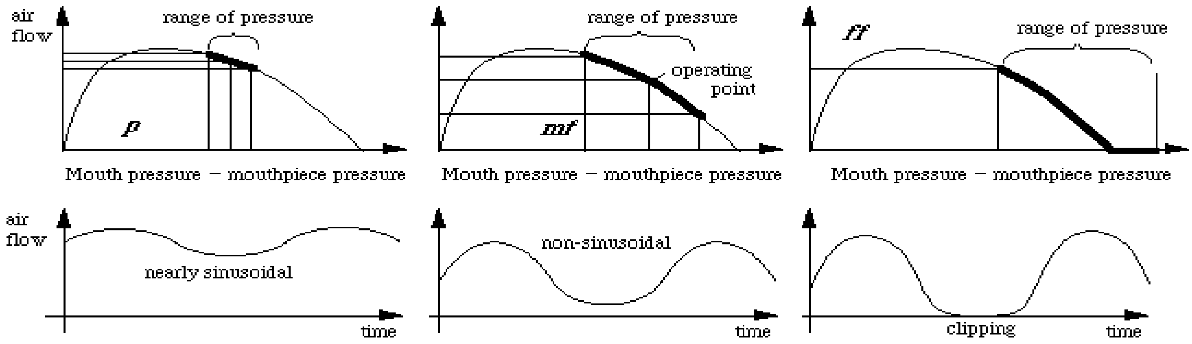


Fig.2.14 Graph representing the relationship between air flow and mouth pressure



Each diagram shows how this sweet spot (the operating point Wolfe refers to) lies within a certain range of pressure depending on the amplitude at which it is being sounded. This factor can be altered by increasing the distance between the reed and the mouthpiece (the lay) and also by varying the thickness of the reed itself. It is for these reasons that a performer's choice of equipment needs to be a balance between the tone desired, the dynamic level needed and the harmonics that are to be stimulated, and these factors will inevitably affect a range of extended techniques depending on this balance.

Fig.2.15 Graphs representing the relationship between air flow and mouth pressure at differing dynamic levels



Multiphonics

Multiphonics are one of the main instances of acoustic phenomena directly affecting sound production for woodwind players. Multiphonics are caused by a mixture of fingerings, tongue position, embouchure alteration and air stream velocity resulting in multiple simultaneous sounds. The result of these external manipulations is the sounding of two or more discernible pitches at the same time from a single resonator. The conclusion of John Backus' paper *Multiphonic Tones in the Woodwind Instruments* (1977) claims that multiphonics are 'heard as perhaps a tone with either two or more simultaneous and distinct pitches, or as a tone with a rough and "beating" quality. They are produced by the simultaneous vibration of the air column at two frequencies that are not harmonically related' (1977, p.599). The 'beating' quality that Backus refers to here is what Weiss & Netti refer to as 'strong oscillation' (Weiss & Nettis, 2010), which in turn perhaps suggests that the seemingly non-specific nature of pitch production produced by multiphonic fingerings needs to be controlled through tongue and larynx manipulation in order to accurately represent the notated music.

Heterodyne Components

Arthur H. Benade explains how this random element of frequency production within multiphonics can be explained by Heterodyne components which are closely related to beating patterns as they relate to the behaviour of two or more normal sine waves (also called sinusoidal components) which are harmonically close together. This is not limited to sounds produced from a single resonator and could equally be worked out for two different instruments, or the addition of the voice to the instrument's sound. John Backus' *Multiphonics in the Woodwind Instruments* (USA, 1978) describes simple relationships between the multiphonic sinusoidal components (A+B) and the heterodyne components (which he defines as B-A and B+A) to create the clarinet multiphonics shown in figure 2.16. Both Backus' article and his main source of reference Bruno Bartolozzi's *New Sounds for Woodwind (1982)* are relatively old texts and thus only consider the orchestral woodwind instruments, excluding the saxophone from their studies. However, I have included an example of Backus' clarinet experiments due to the shared reed-valve system the instruments have and the similar closed tube wavelength behaviours.

Fig.2.16 Heterodyne components in clarinet multiphonics taken from Backus (1978)

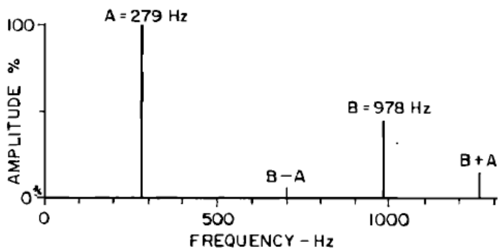


FIG. 14. Components of the clarinet multiphonic on the written note G_3.

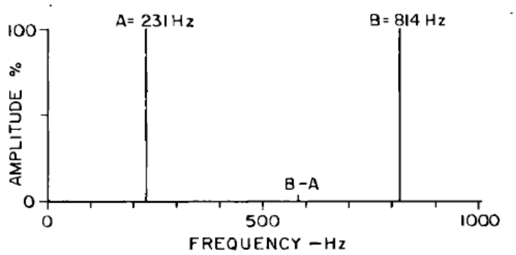


FIG. 16. Components of the clarinet multiphonic on the written note $F\#_3$.

The mixture of sinosoidal and heterodyne components creates the notes we hear within the multiphonic. However, multiphonics on the saxophone tend to be much more strident and complex than the clarinet's multiphonics including intervals of octave, ninths, and twelfths,meaning that there must be other components within a single multiphonic.

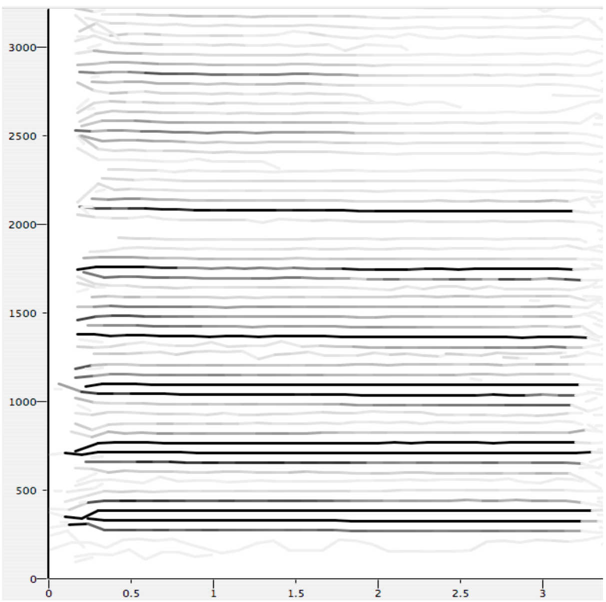
Benade's *Fundamentals of Musical Acoustics* (1976) expands the heterodyne components through the table of relationships as shown in table 6. These equations suggest that there are more patterns to the sounds that we hear from the multiphonic (the heterodyne components) in relation to the chief energy sources of P and Q (the sinusoid components) than Backus suggests. In order to understand the behaviour of multiphonics I have recorded Kientzy multiphonic number 55 on my soprano saxophone (track 36) and analysed it using the SPEAR (Sinusoidal Partial Editing Analysis and Resynthesis) software which is shown in figure 2.17.

Table 6: Benade's table of simple Heterodyne relationships

Original Components	Simplest Heterodyne Components	Next-Appearing Heterodyne Components
P	(2P)	(3P) (2P+Q), (2P-Q)
	(P+Q), (P-Q)	
Q	(2Q)	(2Q+P), (2Q-P) (3Q)

In the following analysis the vertical *y* axis represents the frequency in H*z* and the horizontal *x* axis represents time. There are eight loose groupings of frequencies; the main frequencies in each group are shown in table 7.

Fig.2.17 SPEAR analysis of Kientzy multiphonic number 55 played on the soprano saxophone



In order to ascertain whether or not these audible frequencies are a result of heterodyne components I have inserted the equations from table 6 (represented in italics) in order to outline the numerical relationships. Using these relationships we can assume that the sinusoid components are E4 (P=330 Hz) and F5 (Q=700 Hz). Kientzy indicates in his book on multiphonics that the main audible sounds in this multiphonic

Table 7: Banade's table of Heterodyne relationships with values taken from Kientzy multiphonic number 90. All figures are in Hz

Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8
265 *330 (P)* 380 *435 (P-Q)*	*655 (2P)* 700 *760 (Q)*	*980 (3P)* *1035 (P+Q)* 1085 *1148 (2Q-P)* *1203 (2P-Q)*	1365 *1418 (2P+Q)* *1480 (2Q+P)*	1745	2065	*2296 (3Q)* 2515	2845

(Kientzy number 90) is E5 (659 Hz) not E4. This suggests that the bottom note of this dyad multiphonic is a heterodyne component of 2P rather than a sinusoid component as Kientzy implies. Listening to track 36 there is indeed a lower component audible outside of this dyad which complies with these rules.

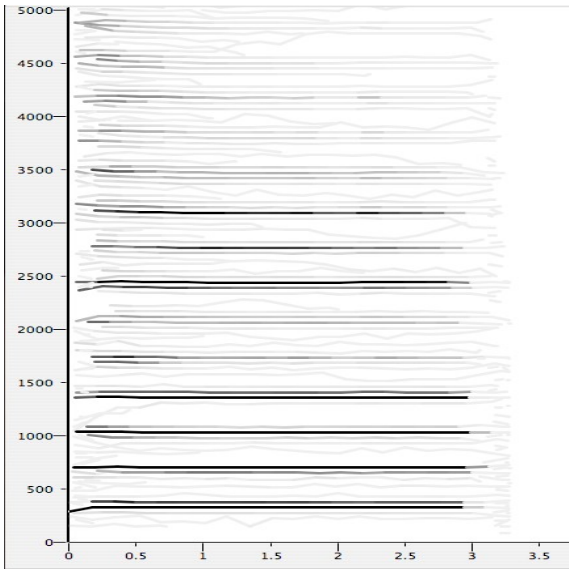
Using the same formulas on Kientzy multiphonic 46 (track 37) for soprano the frequencies can once again be analysed as shown in table 8.

Table 8: Banade's table of Heterodyne relationships with values taken from Kientzy multiphonic number 90. All figures are in Hz

Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8
332 384	*645 (Q-P)* *701 (P)*	980 1029 1080	*1359 (Q)* *1415 (2P)*	1679 1733	*2058 (P+Q)* 2117	2391 2434	*2769 (2Q)* 3471

It is interesting how the third note of the multiphonic (C7 slightly flattened) is actually the result of the heterodyne component of P+Q. From a practical point of view this suggests that the simplest heterodyne components (P, Q, and P+Q) are the easiest to manipulate when performing multiphonics as each of these notes can be isolated by pitching them using the tongue and larynx.

Fig.2.18 SPEAR analysis of Kientzy multiphonic number 46 played on the soprano saxophone



Some of the heterodyne components in this example are sonically very close to one another as shown in table 8; for example Q-P at 645hz equates to a flattened E5 whilst P itself at 701Hz is F5. Also Q at 1359Hz and 2P at 1415Hz both equate to the note F6. These very close frequencies may well explain the dissonance and strong oscillation within these multiphonics created by beating patterns that are generated from sounds that are so close to each other.

It is important for a performer to have an understanding of these relationships when performing multiphonics as it is worth being aware of exactly which partials are present in the sound and therefore which partials need to be suppressed using the tongue and larynx in order to accurately realise the score. It is also possible to emphasise certain pitches within the multiphonic using the same manipulation and this is often useful to highlight pitch relations that are implicit within the composition according to a performer's individual interpretation of these relationships.

Microtones

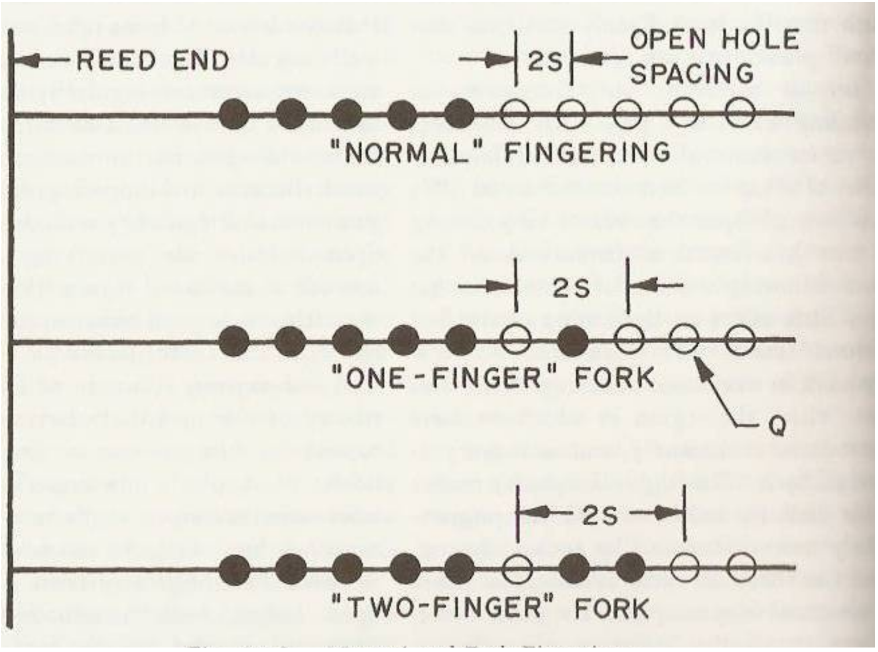
Composers often use microtonal intervals in their music to alter and expand/contract the sounds they wish to hear. A performer has a number of different fingerings available to them which on paper seem to achieve the same quarter or eighth tone but in practice these fingerings often result in slightly different tunings according to the fingering chosen. An understanding of how microtonal fingerings work and how they alter the sound can help a performer to choose the appropriate fingerings based upon the effect they wish to create and the musical context of these micro-intervals.

Due to its conical shaped bore the saxophone employs a system of progressively larger key cups to cover the tone holes, unlike the clarinet, flute or bassoon whose cylindrical shape allows the tone holes (which are all of a uniform size) to be covered directly with the fingers. The saxophonist relies on remotely controlled key cups for nearly every note and this feature of the instrument's design is of huge importance when it comes to playing microtones as saxophonists cannot half-cover tone holes with any degree of accuracy. Half-opening keys can sometimes be achieved but again, due to the remote controlled articulation of the saxophone certain keys tend to control other keys either further up and/or down the instrument's bore. For example one cannot half close the B key without the '*bis*' key (controlling Bb) also being affected, and any key depressed by the right hand will result in the G# key being precluded from opening due to the articulated G# mechanism. This latter example actually denies the saxophone the ability of playing G quarter tone sharp as the required pad is permanently closed by the right hand, which at the same time is the only hand available to alter the note; I will suggest a solution to this problem later in this section.

Fork Fingerings

Benade outlines a fork fingering as 'one in which the regularity of the open-hole lattice is interrupted by closing one or more of its holes. A typical fork fingering occurs when one attempts to flatten a note a semitone by closing the second hole down in what had originally been a series of open holes' (A. Benade 1976 p.451). Figure 2.19 is taken from Benade's book and outlines the behaviour of this 'open-hole lattice' when a fork fingering is introduced into it. The three examples depicted show

Fig.2.19 Diagram showing Benade's 'open-hole lattice'

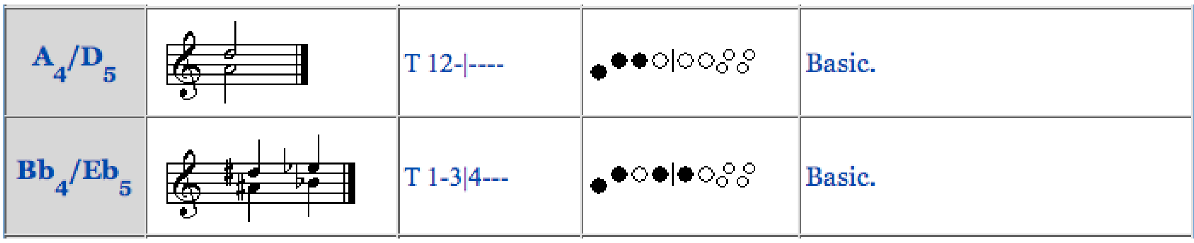


the difference of spacing (2S) between a normal fingering, a single fork fingering, and a double fork fingering. The value 2S clearly increases with the addition of the forked fingering therefore the pitch drops due to the fact that the air travels slightly further in each case. Ronald Caravan observes:

> the result is that the quarter-tone fingerings are detected as producing a 'darker' or 'duller' tone quality. (This can be compared to the variations in tone color due to cross fingerings which must be used to play the chromatic scale on earlier forms of woodwind instruments.) (Caravan, 1974).

Figure 2.20 shows an example of this from the fingering chart for a recorder: an early instrument that relies wholly on fork fingerings to play the chromatic scale.
Notice how the treble recorder's A (as depicted by the lower notes on the stave) can only move to Bb due to a double fork fingering lengthening the space between the holes (2S) and therefore flattening the note above (B) by half a step (Bb).

Fig.2.20 Fingering chart showing a two-finger fork on the recorder taken from
http://www.wfg.woodwind.org/recorder/rec_bas_1.html



A_4/D_5		T 12-|----		Basic.
Bb_4/Eb_5		T 1-3|4---		Basic.

The principle of flattening a pitch using forked fingering is also common to the saxophone and is the basis of playing the quarter tone scale. Figure 2.21 shows a quarter tone scale compiled by renowned soloist and current professor at the Paris Conservatoire Claude Delangle, and is taken from the chapter *The Contemporary Saxophone* in *The Cambridge Companion to the Saxophone (*1998)*.* The first note on the chart (D quarter tone flat) is an example of a fork fingering, where the pads 123-456 are closed but the Bb key is also depressed. This is similar to the fingering for low Bb; however, key 7 has been missed out thus creating a two-finger fork as the Bb key closes both low B and Bb pads thus flattening the D by a quarter tone. This pattern continues for most fingerings; however, it should be noted that some fingerings on the chart mask this fact graphically but in practice the fork fingering is still in place, for example the D quarter tone sharp (the second fingering on the chart) where keys 123-456 are again depressed with the addition of Eb and 7 which are depressed by the same finger. This results in the opening of the Eb key which is between keys 6 and 7 creating a one finger fork with 2S being the distance between key 6 and 7 and thus flattening the note E. The fingering for the note Ab (or G#) is problematic, however, as it involves keys 123 and the addition of the special G# key leaving only keys 456 available in the right hand to create a forked fingering. The problem here is that the saxophone's articulated G# mechanism precludes a fork from being produced as any key that is depressed be it 4, 5 or 6 automatically closes the G# pad due to a bridging mechanism.

Fig.2.21 Quarter-tone fingering chart, taken from Delangle and Michat (1998)

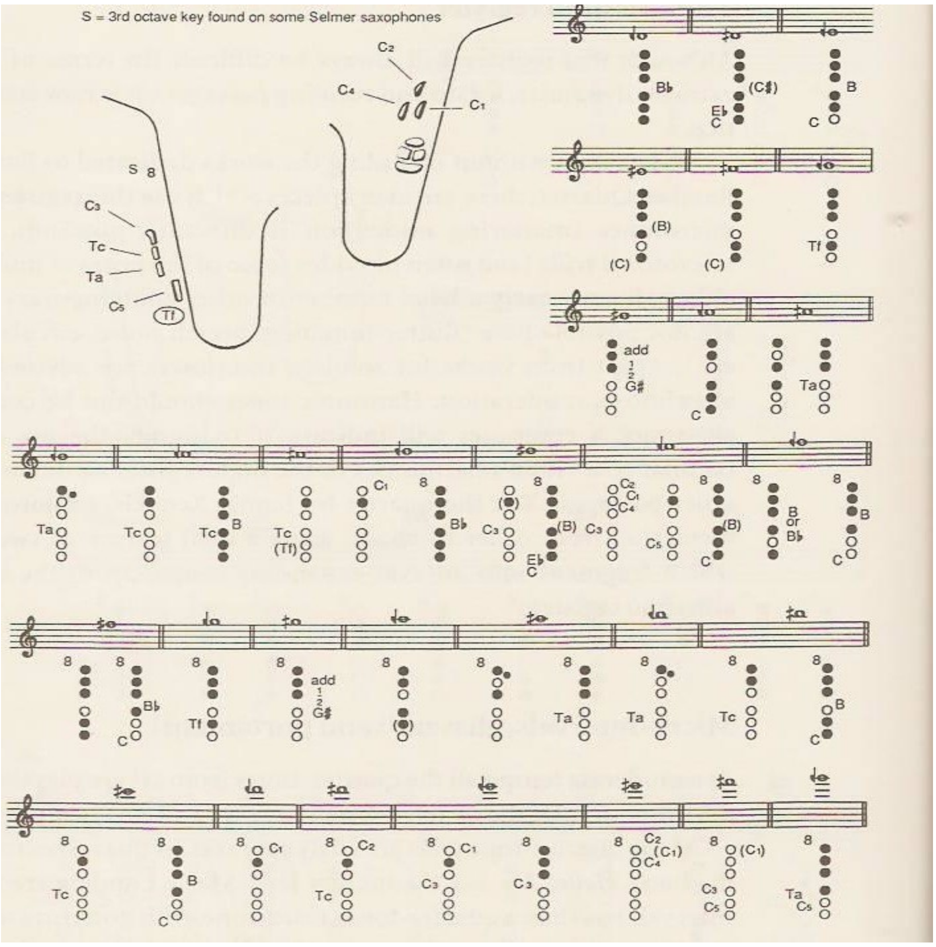


Figure 2.22 (a) shows the bridging mechanism at its resting position; key 4 is open and the bridge is open allowing the G# pad (which is closed) room to open. Figure 2.22 (b) shows the G# pad in its open position when the G# key is depressed, and figure 2.22 (c) shows the bridging mechanism automatically closing when key 4 is depressed (this also happens when key 5 or 6 are depressed). Indeed in Ronald Caravan's Fingering chart included in his study he simply writes N/A each time G quarter tone sharp is mentioned, and also the online fingering guide (www.wfg.woodwind.org) also has no solution as shown in figures 2.23 and 2.24. The solution for playing the note G quarter tone sharp is suggested by Delangle in his fingering chart depicted in figure 2.21 as half closing the G# key denoted by the addition of the note 'add ½ G#'. The technique of half-closing has also been discussed in reference to Weiss & Netti's book in which it is suggested that in order to pitch a G

quarter tone sharp the performer must 'finger a G# and lay the fingernail of the index finger of the right hand on the edge of the tone hole of the F or F# key and closing it until it touches the fingernail.

Fig.2.22(a) G# bridge mechanism,
G# key not depressed, right hand not depressed

Fig.2.22(b) G# bridge mechanism,
G# key depressed, right hand not depressed

Fig.2.22(c) G# bridge mechanism,
G# key depressed, right hand depressed

Fig.2.22(d) altered G# bridge mechanism,
G# key depressed, right hand depressed

This fingering with half key is complicated, but it is, in fact, a fingering' (Weiss & Netti, 2010 p.15). This is particularly difficult to judge in quick passages as the task of half depressing a key is, as Weiss & Netti have stated, so complicated as to be impractical. Another solution is printed in the second movement of Denisov's Sonata for Alto Saxophone and Piano (1973) where in the second movement Jean-Marie Londeix (whom the piece is dedicated to) suggests the flattening of the note G# is achieved not by half opening the pad but by releasing the pressure of the embouchure through the instruction 'lâcher les lévres' and an illustration for the technique is included. In the case of this movement and its slow tempo this technique can be successfully used, but in quick passages there can be no real accuracy when using this technique.

Fig.2.23 Fingering chart taken from Caravan (1974)

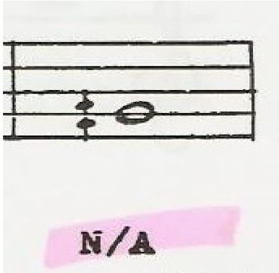


Fig.2.24 Fingering chart taken from http://www.wfg.woodwind.org

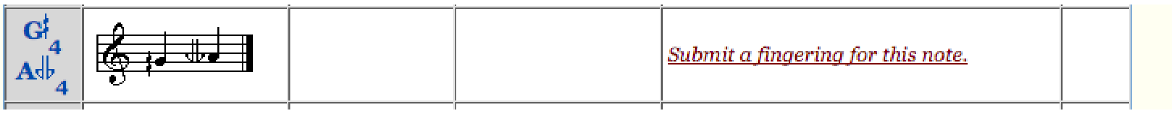
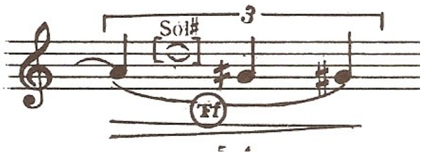


Fig.2.25(a) Indication and symbol for the release of lip pressure to play G quarter tone sharp

Fig.2.26(b) Denisov's Sonata for Alto Saxophone and Piano (1973), movement II, line 4



The most successful method I have come across was told to me by the German improviser Frank Gratkowski who pointed out that the only key on the right hand that is not used in conjunction with the left hand during normal playing is key 6, and so the mechanism which links the other keys and therefore the bridging mechanism with key 6 can be altered so the fingering 123-6 (the same fingering as a normal F# on the flute) results in the bridging mechanism only being closed half-way. The addition of the G# to this fingering will therefore open the G# pad half-way as Delangle suggests and will produce the note G quarter tone sharp as shown in figure 2.22(d). This method solves the problem of quick passages as it gives the saxophonist a definite fingering for the note rather than half-closing pads or altering the embouchure (track 38). In order to demonstrate the difference between the two different methods of producing the note G quartertone sharp, I have recorded the gesture shown in figure 2.26(b) using both the 'lâcher les lévres' technique (track 39) and the same gesture using this mechanical alteration (track 40).

The different methods of achieving microtones on the saxophone, be it half opening keys or the combinations of one and two fingered forks in the open hole lattice, offer the performer a great deal of choice as to which combination of production methods will suit an individual composition. It is therefore up to the performer to choose which combinations are best based on their own understanding of the work and the relationships of pitch, interval, timbre and rhythm they wish to emphasise.

Part III: Understanding the Importance of Physiology

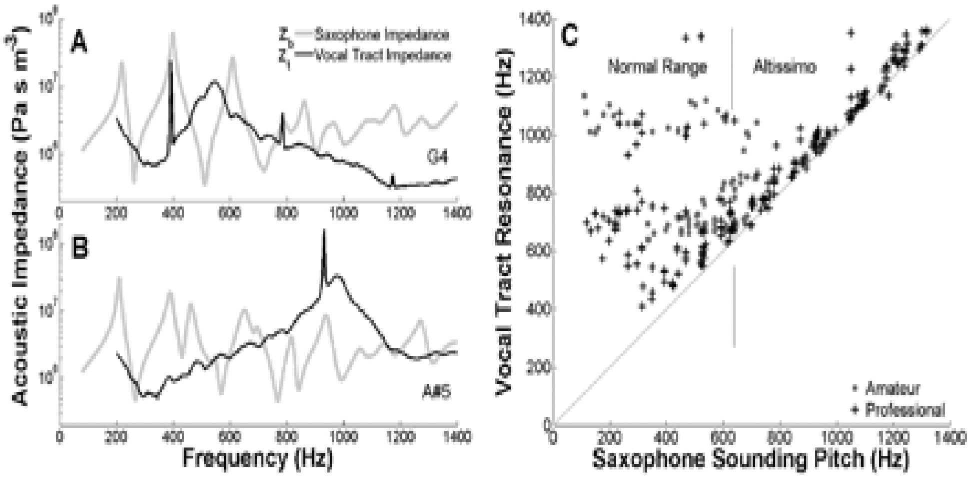
It has been mentioned in the previous sections that the performer can manipulate extended techniques such as microtones, multiphonics, harmonics and the altissimo register through use of the tongue, larynx and oral cavity. These physiological techniques are vital for the production and manipulation of these sounds and without them the choices relating to interpretation and realising the score accurately is impossible as not all techniques behave in ways that are written down in the music. It is therefore the performer's role to use these techniques expressively by considering the various incarnations a multiphonic or microtone can take and choosing the method of manipulation that serves their interpretation the closest. Alongside the single valve function of the reed/mouthpiece combination there are other aspects that affect the workings of the air column, the most important of these being the physiology of the performer and how the performer's understanding of the vocal tract resonance; larynx and tongue position affect how the harmonics of the saxophone can be manipulated when, for example, playing in the altissimo register. It is only through an understanding of how physical manipulations of one's body alters the sound of the saxophone that any attempt at altissimo playing and techniques such as spectral sweeps, portamento or playing individual partials of a multiphonic can be made at all successful.

Many players have reported anecdotally how tongue and throat positions are important for sounding extended techniques but it is not generally understood by performers what is happening when we play or how these manipulations help the performer achieve their interpretative goals.

Vocal Tract Influence

In an experiment which measures the resonances within the player's vocal tract Chen, Smith and Wolfe note that 'depending on the shape of the mouth and tongue, vibrations in the air in the vocal tract can be enhanced or inhibited at different frequencies. At the frequency of a resonance, a large sound pressure is produced' (Chen, Smith, Wolfe, n.d.). This suggests that the resonance within the vocal tract is significant in producing a strong sound on the instrument. It is also noted that 'In the high ('altissimo') range, the professional players in this study all consistently tuned a strong resonance of the vocal tract to a frequency slightly above that of the note to be played' and also that 'none of the amateurs in this study tuned the vocal tract and none of them could play in this altissimo range' (Chen, Smith, Wolfe, n.d). These statements indicate that the tuning of the vocal tract to a similar resonant frequency to the note required when using harmonics is imperative to their production. Figure 2.27 is taken from Chen, Smith and Wolfe's paper entitled *Experienced Saxophonists Learn to Tune Their Vocal Tracts* (n.d.) and shows the position of performer's vocal tracts relative to the pitch they are attempting to play. Both graphs clearly show that a vocal tract resonance which is close to the desired pitch is

Fig.2.27 Graph indicating the relationship between vocal tract resonance with resulting impedance and frequency played



important in the normal register but is vital when playing in the altissimo register. In another experiment Scavone et al recorded the sound pressure levels (SPL) to indicate the vocal tract influence of four multiphonics as shown in figure 2.28. The spectral densities of these multiphonics were then recorded from two different players; subjects B and D. Figure 2.29 shows those results with subject B at the top and subject D underneath.

Fig.2.28 The four multiphonics used in Scavone et al's experiment to measure sound pressure levels

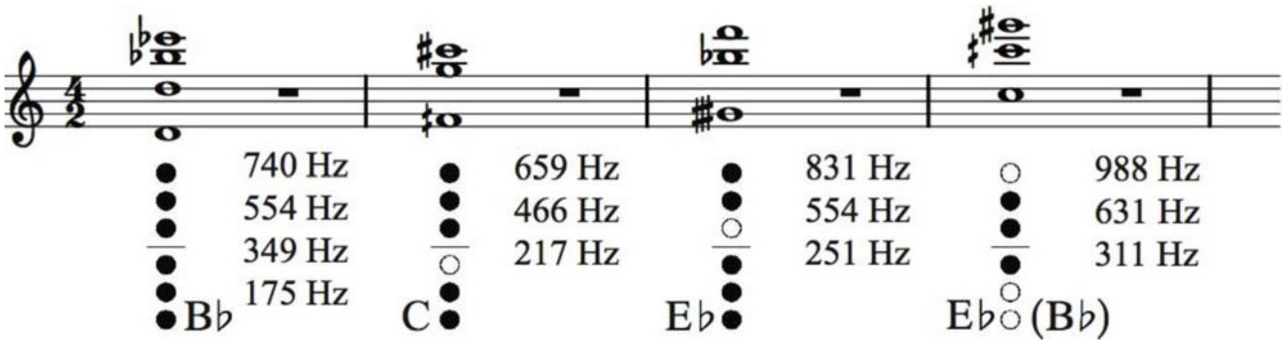
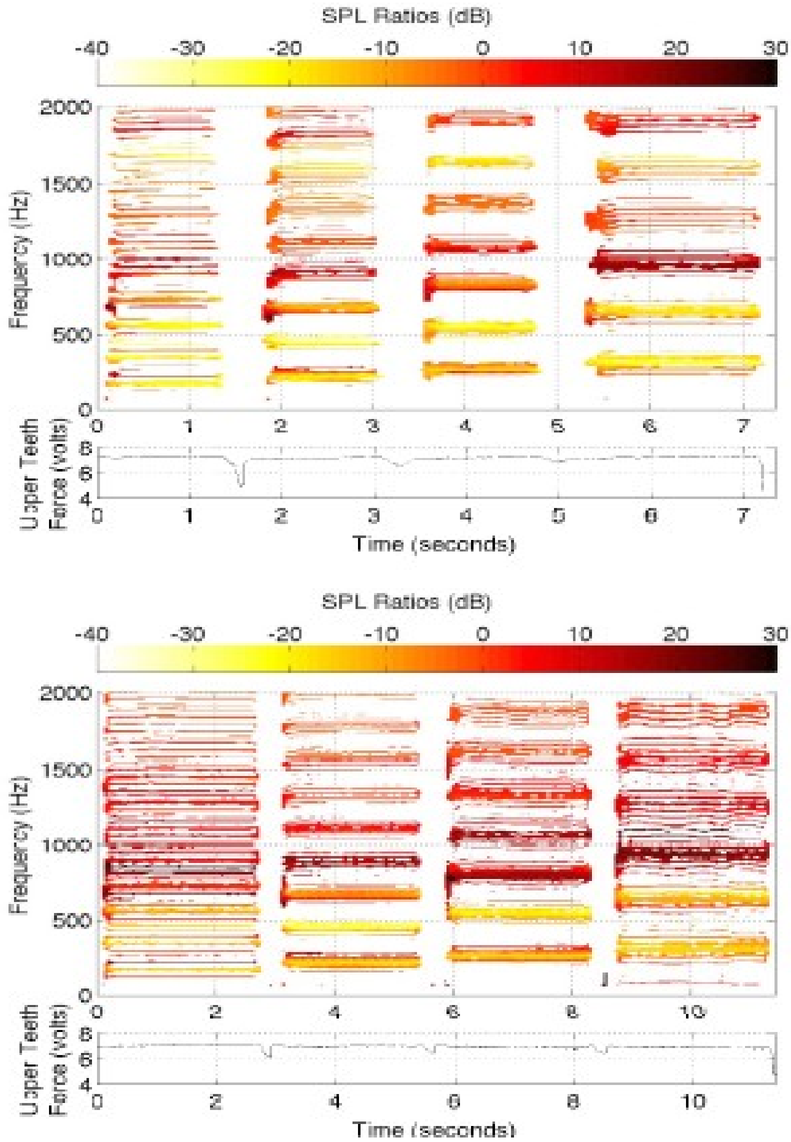


Fig.2.29 Graphs indicating the sound pressure levels measured for each multiphonic by subject B (top) and subject D (bottom)



The findings from this experiment states that:

> Multiphonics involve oscillations of the reed based on two inharmonic downstream air column resonance frequencies and their intermodulation components. Two relatively easy and two more difficult multiphonics were chosen for analysis with respect to potential vocal-tract influence. The four multiphonic fingerings and their approximate sounding notes are illustrated in Fig.[2.28]. Figure [2.29] shows the SPL ratios for four different multiphonics, as played by Subjects B and D. The sounds produced by the two subjects differed significantly. From the plots, there are more spectral components evident in the sounds of Subject D. We expect that a player can influence the sound quality of a multiphonic by aligning an upstream resonance with one or more components. For example, both subjects appear to reinforce a group of partials in the range 875–1075 Hz for the last multiphonic. SPL ratio levels for

> Subject D were, across all tasks, generally higher than those of Subject B. This suggests that Subject D makes use of stronger upstream resonances, which likely explains both the higher ratios for this task, as well as the greater spectral density of the multiphonic sounds
>
> (Scavone, Lefebvre, da Silva, 2008, p.2397).

It is interesting that two players should make such different sounds when performing multiphonics; however, it is not too surprising taking into account the myriad of variables in vocal tract, tongue, and larynx positions. The way these multiphonics are played and how those variables are manipulated are usually a combination of experience, muscle-memory (often referred to as 'feel') and listening to the resultant sounds. As a demonstration I have recorded the same multiphonics to see how my results differ from subject B and D, and if my spectral sounds agree with either of them. It is conclusive from the SPEAR analysis in figure 2.30 (track 41) that my playing is similar to that of subject B in its spectral density. I am not equipped to measure the sound pressure levels involved in vocal tract manipulation; however, we may assume from Scavone, Lefebrve and da Silva's evidence that the sound pressure level in the vocal tract affects the spectral density of the overall sound. In order to test the importance of sound pressure levels on the air stream I decided to repeat the experiment myself but using my open lay mouthpiece (figure 2.31, track 42) and as we have already seen this mouthpiece can alter the harmonic density of the overall sound and thus alter the tone of the instrument. I found that my results this time were largely the same as they were the first time and there was little change to the spectrum. In listening to the recordings of these two examples the listener can discern some difference in timbre between the two mouthpieces, showing the effect of the chamber design but no real difference in spectral density. These findings agree with Scavone, Lefebrve and da Silva's conclusion that it is the instrumentalist and the sound pressure level present in their vocal tract that significantly affects the overall sound of these multiphonics to the point that different notes are produced, not differences in equipment or setup. Another useful conclusion drawn from this paper is an indication of the SPL of a technique the authors call 'bugling' and to which I have already referred as playing the harmonic series or a 'spectral sweep' when done in one continuous gesture. Figure 2.32 outlines a proportional increase between the SPL and each successively high partial. This result suggests a direct link between the SPL of the vocal tract and playing in the higher registers agreeing with Chen, Smith and Wolfe's data.

Fig.2.30 SPEAR analysis of the author playing the multiphonics in Scavone et al's experiment on the closed Vandoren Optimum AL3 mouthpiece

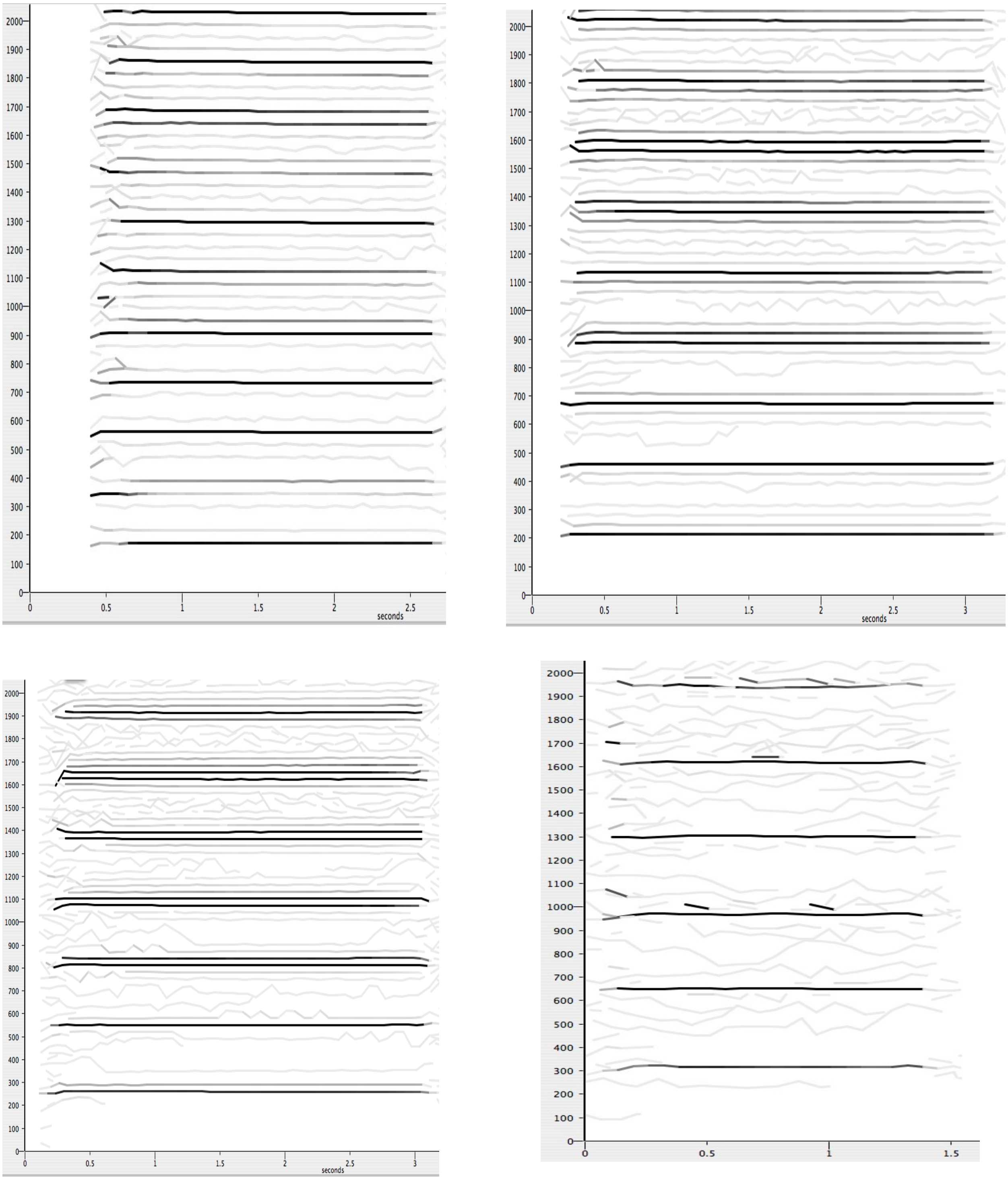


Fig.2.31 SPEAR analysis of the author playing the multiphonics in Scavone et al's experiment on the open Freddie Gregory Model F6 mouthpiece

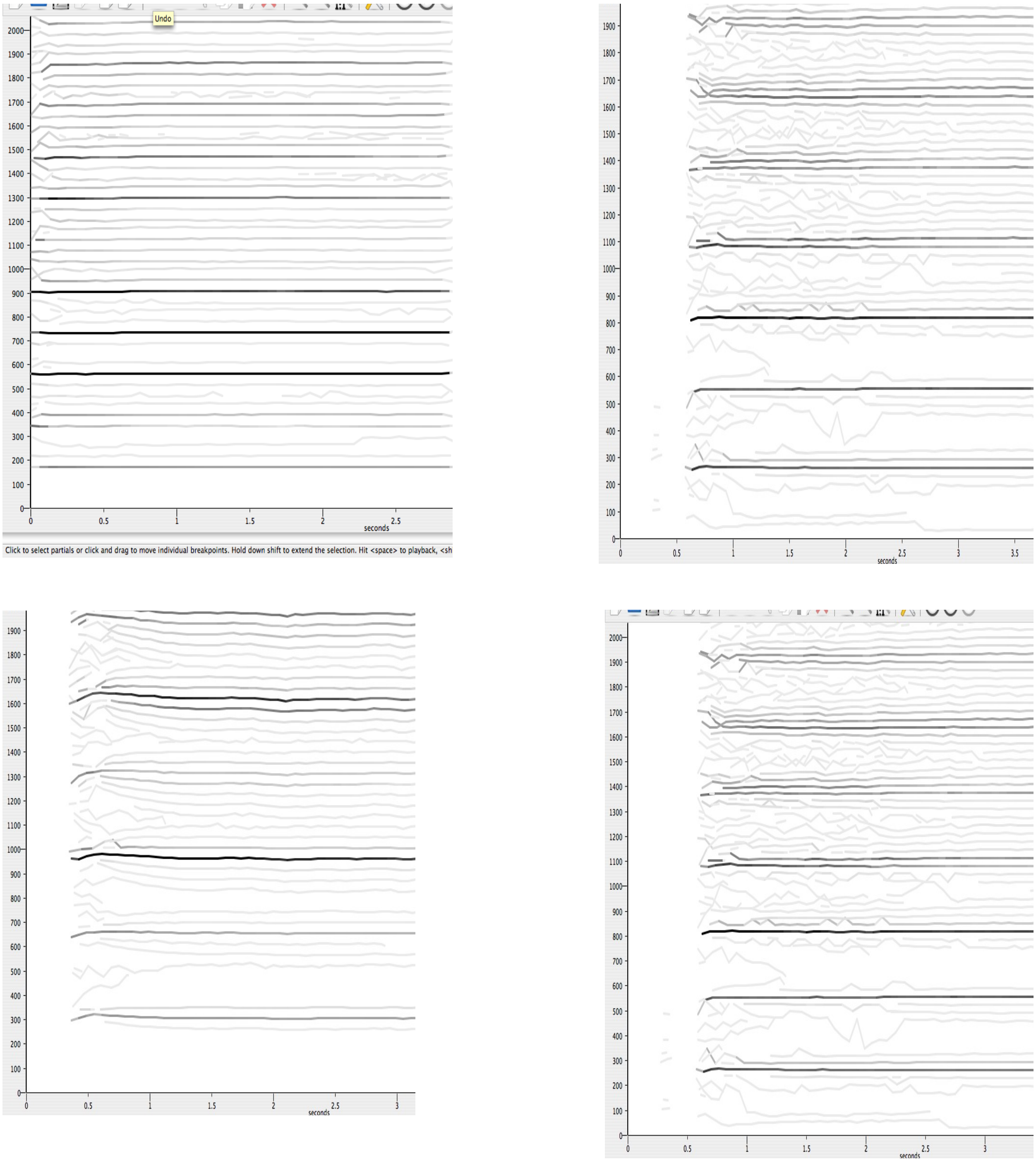
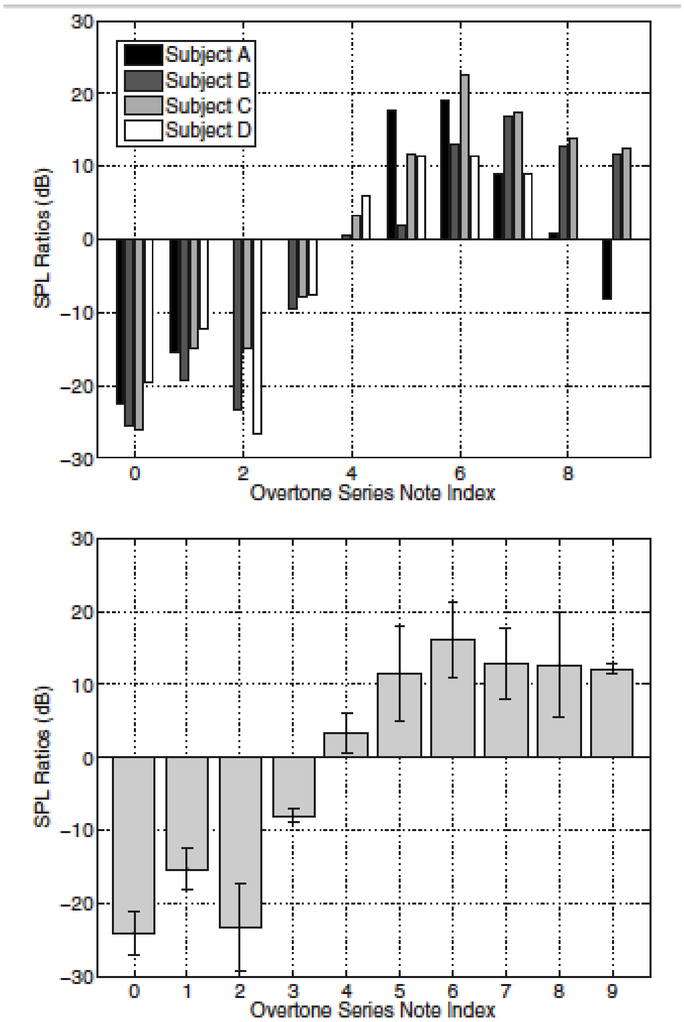


Fig.2.32 Graph indicating a proportional link between higher frequencies and higher sound pressure levels (SPL)



It can therefore be concluded that in order to get techniques which involve utilisation of the harmonics to sound at all, the performer needs to understand this vital relationship between the vocal tract, tongue position and air column. This is also true of the manipulation of extended techniques as the player can elect to emphasise certain notes of a multiphonic, or begin and end a spectral sweep on certain partials and it is only through this understanding of physical manipulation that these nuances can be achieved.

The Effect of the Larynx

It has been demonstrated how sound pressure levels caused by the standing waves inside the cone of the saxophone are important to the sound, and so it is necessary to understand the role of the larynx which, in addition to the embouchure, works in tandem with the reed system to create a valve that the air passes through before it reaches the mouthpiece. The larynx is of course especially important when using the technique of singing and playing simultaneously as this cartilagenous structure deep within the throat is the home of the vocal folds and functions to open and close the aperture between them to regulate air from the lungs when forming speech and singing. The larynx has become key to certain saxophonist's technique. Players like John Harle are beginning to write about these issues, but saxophonists mainly refer to high pressure air through the larynx as 'opening up the throat' which implies that a certain amount of muscle memory is employed in order to sound multiphonics, harmonics and spectral sweeps.

In the book *Singing: The Physical Nature of the Vocal Organ (1976)* Husler & Rodd-Marling describe the vocal folds as follows: 'Two muscular folds covered by an elastic membrane are placed within the cartilaginous framework shown in figure [2.33]. It is their vibratory action which, by turning the outflowing breath into sound, is most directly responsible for the production of voice' (Husler, Rodd-Marling, 1976 p.17). Arthur Benade refers to the larynx as 'A Self-sustaining oscillatory flow controller' (Benade, 1976 p.363) and goes on to explain that 'the [vocal] cords are given a shape and spacing that permits the aerodynamic forces which arise from the air flowing between them into oscillation. However, the speed of the airflow only slightly influences the frequency of this oscillation; the predominant control comes from the mass of the vocal cords and the muscle tension set up in them' (Benade, 1976 p.363). Benade goes on to explain the function of the larynx and how it controls the air flowing through it without interrupting the oscillatory function of the vocal cords using the following statements:

1.Fluids (including air) tend to flow from regions of high pressure towards regions where the pressure is low.

2. As a consequence of the influence of pressure on fluid flow, we recognise that if we see an increasing flow velocity of a fluid as it moves from one point to another in its travels, we can deduce that the pressure at a high-velocity spot must be lower than at the low-velocity point from which the fluid came. One cannot speed anything up without arranging to have an excess of force acting behind it.
3. When a fluid flows steadily and continuously in a long duct, we expect the velocity of flow to be higher in any narrow parts of the duct than in the wider parts.
4. A joint implication of statements 2 and 3 is that we should expect the fluid pressure in the narrow parts of a long duct to be lower than it is in the broader parts.

(Benade 1976, p.363-364)

This is of course continuously making reference to Bernoulli's principle as outlined in the embouchure section of this chapter; however, when applied to the larynx a fifth statement also applies:

5. The presence of viscous friction that is normally found in a fluid and between the fluid and its containing walls does not change the qualitative correctness of statements 1 through 4. However, it leads to a reduction in the total amount of fluid that passes through the system per second under the influence of a given driving pressure of the source.

(Benade 1976, p.363-364)

Fig.2.33 Diagram of the larynx taken from Husler & Rodd-Marling (1976)

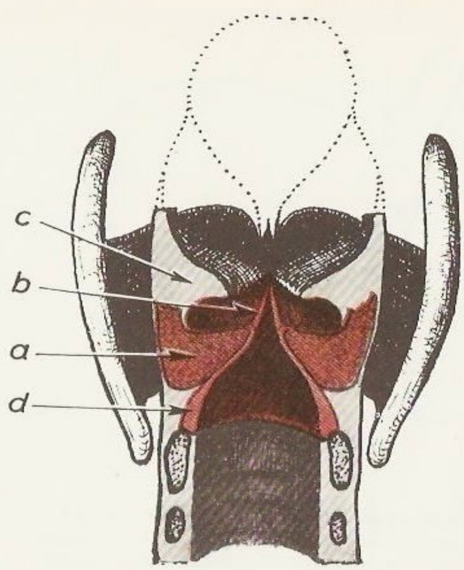


FIG. 10. Diagrammatic section of vocal folds seen from behind. (*a*) Vocal lip (see Fig. 11). (*b*) Vocal band (see Fig. 12). (*c*) Ventricle bands: 'false cords.' (*d*) Conus elasticus.

This statement reinforces Benade's summarisation of the larynx as being a 'flow controller' above all else and also explains how the quality of sound produced is not affected by volume of air passing through the system. Figure 2.34 shows an analogy for this system with M=mass acting as a larynx controlling the pressures and velocities within the air stream.

Fig.2.34 Diagram showing 'a mechanical analog of the larynx' taken from Benade (1976)

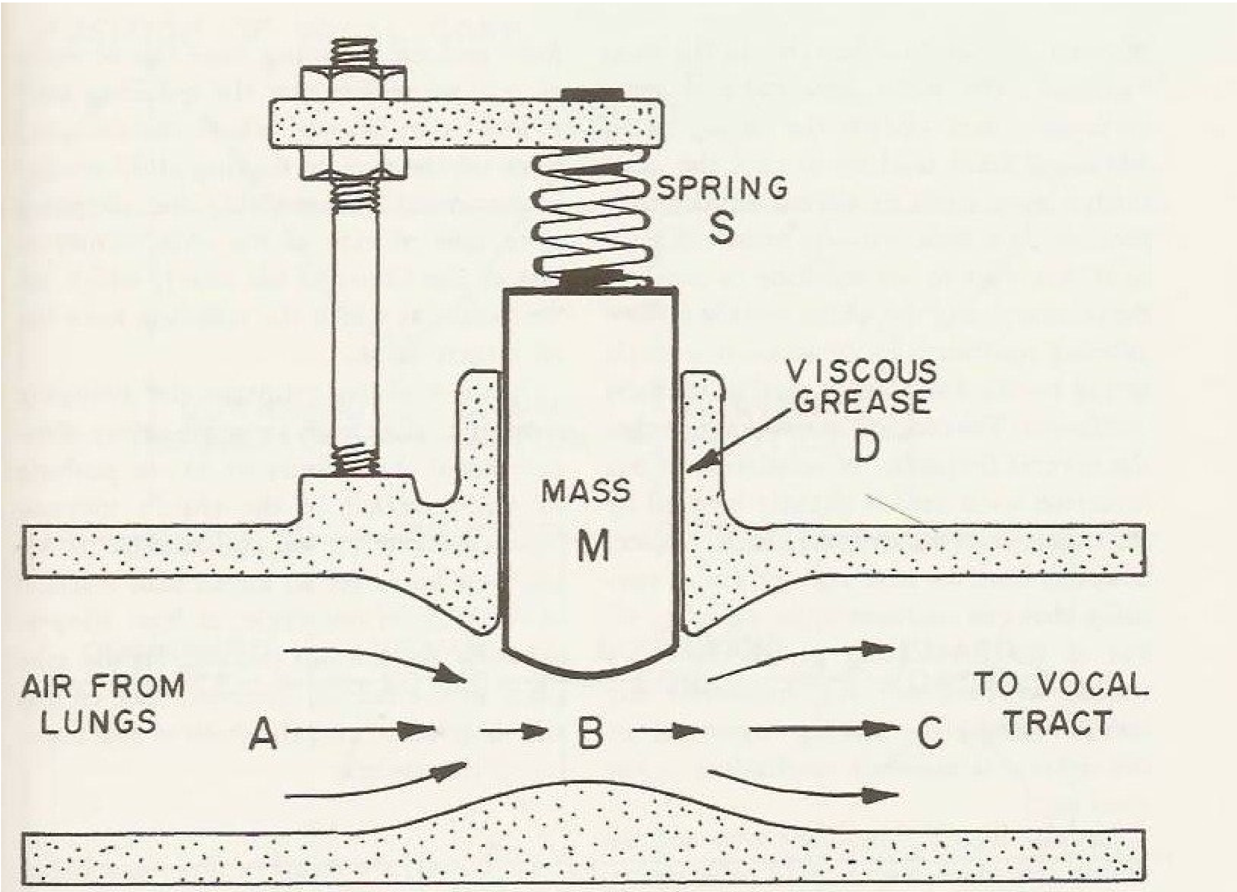


Fig. 19.2. A Mechanical Analog of the Larynx

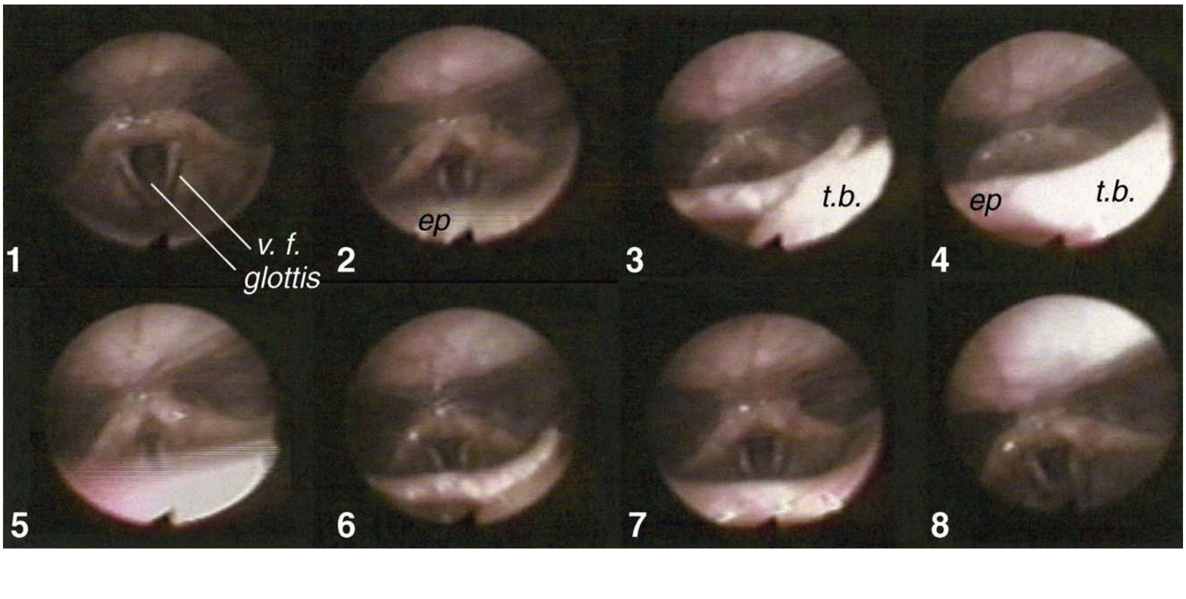
The idea behind this analogy of the larynx is that it displays Bernoulli's principle in that the air from the lungs marked A and the air marked C are at low pressure as compared with the air marked B, which is under high pressure from the mass marked M. In accordance with Bernouilli's principle the velocity of the airflow will increase as it moves from high to low pressure and therefore the velocity of C is greater than that of A. In saxophone playing, the mass marked M can represent the larynx, the tongue, or a mixture of the two.

There have been a number of studies which record the effect of the larynx on woodwind playing usually using endoscopy and/or videofluoroscopy to record the positions of the player's larynx whilst producing sounds on their instrument. In an article by Matthias Weikaert and Josef Schlömicher-Thier the authors explain that the:

> In singing the tone is produced in the larynx through vibrations of the vocal folds. These vibrations create the primary laryngeal sound (voice source signal) using subglottal pressure (during expiration) and intrinsic vocal fold muscles and other tissues. This primary laryngeal sound is then modulated by the resonator. The principles of breath support are similar for singing and playing wind instruments. However, in comparison with a singer, the wind instrumentalist needs greater breathing pressure for both the single reed instruments (I.e. the clarinet and saxophone) and especially for the double reed instruments (such as the bassoon and oboe)
>
> (Weikert, Schlömicher-Thier, 1999 p.265).

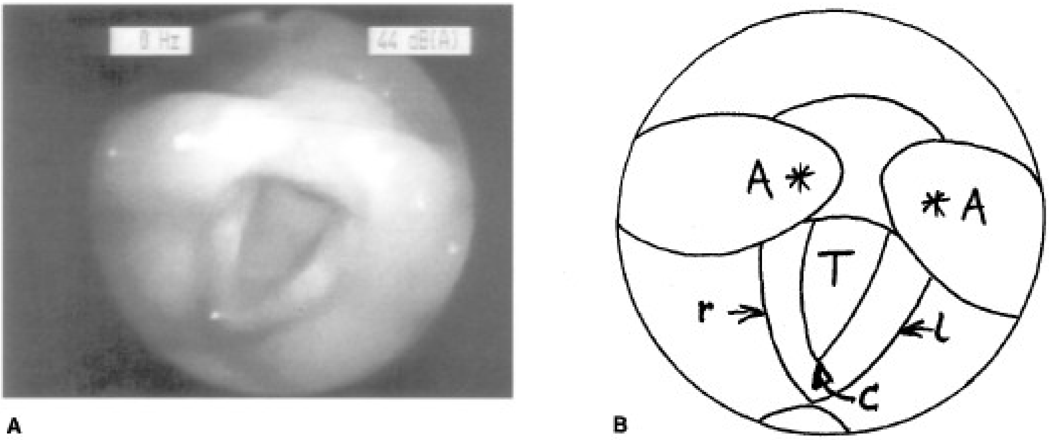
This study along with a second study entitled *Videofluoroscopic and Laryngoscopic Evaluation of the Upper Airway and Larynx of Professional Bassoon Players* by Kahane et al outlines data that shows minor alterations in the shape of the larynx aperture. However, these results serve only to show minor adjustments when playing simple musical exercises such as crescendo/diminuendo, differing amplitudes and articulations on the tune 'Scarborough Fair'. Below is an illustration from the article by Kahane et al showing the differences in laryngeal positions in a bassoon player whilst producing vibrato.

Fig.2.35 Endoscope of a bassoonist producing vibrato



It is clear from this illustration that the larynx does indeed move to regulate air flow as the aperture between the vocal folds clearly changes from picture 1-8. Weikert and Schlömicher-Thier's article also include endoscopic pictures with an added illustration of positions:

Fig.2.36 Endoscope plus illustration of a saxophone player's larynx during inspiration



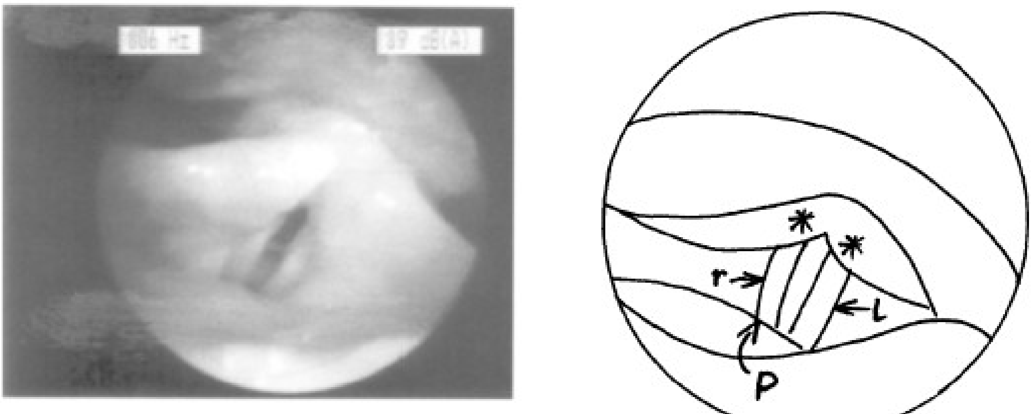
A B

FIG. 1. A. Saxophone player's larynx in inspiration: vocal folds greatly *abducted* (respiration position). **B.** Schematic drawing:

A	*	humplike process of the arytenoid cartilage tilted inward and forward.
r	→	(= right) vocal fold (r) in widely abducted position
l	←	(= left)
C	↑	anterior commissure
T	0	tracheal lumen

The above illustration shows an open larynx during inspiration as one would expect, but the following illustrations show little difference in larynx position:

Fig.2.37 Endoscope plus illustrations of a saxophone player's larynx whilst playing forte high (top), forte glissando to piano (middle) and forte low (bottom)

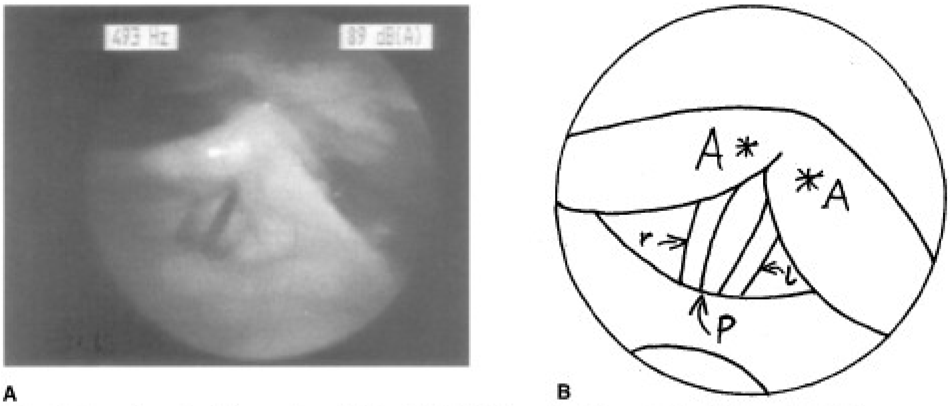


A B

FIG. 2. A. Playing forte: 806 Hz = A 2, 89 dB, microphone distance 0.5 m. **B.** Schematic drawing:

A	*	humplike process of the arytenoid cartilage tilted inward and forward
r/l	→←	Vocal folds right and left, adducted in intermediate position
P	↑	Petiole protruding slightly into (and thus narrowing) the laryngeal aperture

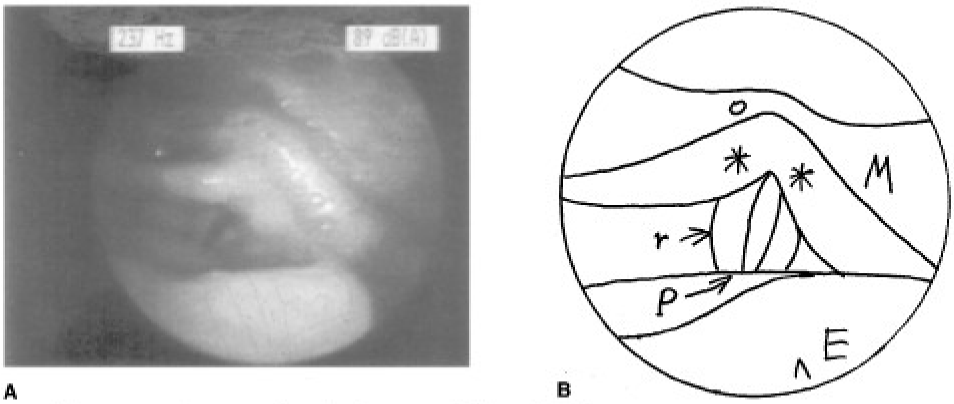
This is equivalent to a muscle tension dysphonia (MTD) Type 2-3 according to Morrison.



A B

FIG. 3. A. Saxophone player's larynx, forte, 493 Hz = C 2, 89 dB, microphone distance 0.50 m. **B.** Schematic drawing:

A	*	Process of the arytenoid cartilage left tilt
r/l	←/→	Right and left vocal fold adducted to paramedian position
P	→	Prominent petiole narrowing laryngeal aperture



A B

FIG. 4. A. Saxophone playing from forte glissando to piano. **B.** Schematic drawing:

A	*	Process of the arytenoid cartilage slightly relaxed and upright again
P	→	Petiole still prominent
E	^	Epiglottis (upper part)
M	0	Accumulation of mucus, postcricoidal

It is of significance that the larynx is much more open when producing higher tones (806Hz) than it is when playing low notes (493Hz). This is due to the sound pressure level produced when tuning the vocal tract for harmonics playing.

Benade's description of the larynx mentions that 'the [vocal] cords are given a shape and spacing that permits the aerodynamic forces which arise from the air flowing between them into oscillation. However, the speed of the airflow only slightly influences the frequency of this oscillation; the predominant control comes from the mass of the vocal cords and the muscle tension set up in them.' (Benade, 1976 p.363). It is because of this fact that the saxophonist can reSonata the vocal cord at the same time as playing normally on the saxophone, singing whilst they play or 'growling' as it sometimes referred to. Ronald

Caravan refers to this technique in his thesis *Extensions of Technique for Clarinet and Saxophone* (1974) by introducing various ways the instruments can produce multiple sonorities:

> 'Aside from equipment modification, there appears to be three ways of achieving multiple sounds with the clarinet or the saxophone. First, there is the simultaneous combination of single tones and vocal sounds. A second way involves the use of fingerings which would normally result in single tones but calls upon the performer to make such distortions in his tone production that multiple sounds result. The third method involves the use of special fingering combinations which enhance the possibility of multiphonic production themselves.'
>
> (R. Caravan, 1974 p.1).

Singing and playing works through the use of the larynx as a secondary resonator to the saxophone's reed and in this way creates multiple sonorities from the instrument. This technique does not work on the same principle as multiphonics which one could define further as multiple sonorities from a single resonator, and the two techniques are used in their own rights even though they result in similar heterodyne components which make up the sound.

The Importance of Tongue Position

As has been mentioned in preceding sections, one of the most important principles in airstream manipulation is Bernouilli's principle. I have described this principle in relation to the reed and mouthpiece combining to create a valve through which the air is forced at high pressure thus increasing its velocity (see figure 2.34). This effect can also be achieved before the air hits the reed and mouthpiece set-up by altering the proximity of the tongue towards either the hard or soft palate, creating a similar valve system which forces air from low to high pressure thus increasing its velocity. It is this placement of the tongue that is vital to producing harmonics, playing in the altissimo register, isolating single sounds within a multiphonic and blending other pitches in and out of a multiphonic accordingly. Walter Edward Carr explains the relationship between the aperture opening of the throat (larynx) and the position of the tongue whilst playing harmonics on the saxophone: 'The saxophone group raised the tongue to play the middle and high register harmonics and sharply dropped the tongue to produce the extreme harmonic tone... The saxophone group had a dramatic increase in throat aperture when executing the extreme harmonic tone' (Carr, 1974). We expect to see an open larynx and therefore increased volume of air for the harmonics but the drop in tongue position is a surprise as it does not comply with Bernouilli's principle. This highlights a flaw within Carr's methodology as indeed the throat aperture may increase to allow a great volume of air through, but there is no mention here of the tongue and its proximity to the soft palate. This is borne out in Carr's own background research where he states that a videoflureographic study of trumpet players by Amstutz in 1970 concluded that 'The tongue arched as the pitch ascended, creating a smaller aperture between the tongue and palate.' However, Carr's data appears to contradict this conclusion as can be seen from the following table:

Fig.2.38 Table taken from W.E. Carr (1974) outlining tongue proximity in mm to the roof of the mouth when playing in different registers of the woodwinds

Table 34. Means (in mm.) of tongue dimensions for each group of woodwind instruments playing harmonics.

Harmonics	Flute	Oboe	Clarinet	Bassoon	Saxophone
Registers					
Low	14.58	16.24	17.18	24.24	22.21
Middle	14.91	16.59	15.63	23.80	21.97
High	17.77	18.17	22.26	24.18	19.60
Extreme	17.77	-----	26.10	23.83	22.69

In the case of each woodwind instrument the tongue position (measured as the gap between the tongue and the palate) appears to increase to produce the extreme register whilst playing harmonics. Eugene Rousseau presents a reason for this increase by observing that 'in order to have the finer airstream required to emit the high tones successfully, even fluoroscopic studies disprove the notion that the throat must be open. Thus, the concept of mouthpiece pitches is virtually indispensable, since the player can relate the feeling of embouchure and air to a real pitch level on the mouthpiece' (E. Rousseau, 1978 p.69). Rousseau's main method for the production of the high tone is to begin with a specific pitch produced from the mouthpiece alone, and to use this as a reference point to manipulate the extreme harmonics. Rousseau goes on to describe his notion of relating a 'feeling' to the manipulation of the throat and tongue positions:

> 'When the above-normal tones are played, a proportionally smaller quantity of air is used as the frequency of vibration increases. In other words, as one plays higher the airstream becomes increasingly smaller. This phenomenon accounts for the unusual feeling inside the mouth that the performer experiences when first playing high tones. It has often been described as an "open throat", an unfortunate term for more than one reason. In the first place, ambiguity often takes place in the mind of a saxophonist, or any wind player for that matter, who, for the first time is told to keep an "open throat'. What is being referred to is the inside of the mouth and throat, and its shape whilst playing, although it is impossible to see any of these shapes and functions! Even in recent studies using the technique of fluoroscopy, the consideration of tongue position, throat opening, etc. -- while they may ostensibly be observed and estimated – must, in the final analysis, be translated into a language that will produce a meaningful result'
>
> (E. Rousseau, 1978 p.69)

Relating harmonics to a specific 'feeling' is echoed in Marcus Weiss and Giorgio Netti's much more recent book: 'A prerequisite for playing harmonics is a flexible embouchure and a good ear. While playing an overtone series on a fundamental starting from the bottom, something happens in the throat area that is very similar to singing. The higher the tone played, the narrower the feeling in the throat and thus, the higher the "seat" of the tone in the head, also in the nose. Just as in singing, one must search for this "positioning" of the throat and head resonance in saxophone playing' (Weiss & Netti, 2010 p.171). Weiss & Netti refer to this 'feeling' as 'physical-acoustic memory' and suggest it is similar to the method used by singers to develop their highest tones. This importance of throat position in singing in order to aid Weiss & Netti's idea of physical-acoustic memory is often taught and thought about as vowel shapes. Vowel shapes, and their importance to the oral cavity, are discussed in Husler and Rodd-Marling's book on singing (all terms relate to parts of the larynx):

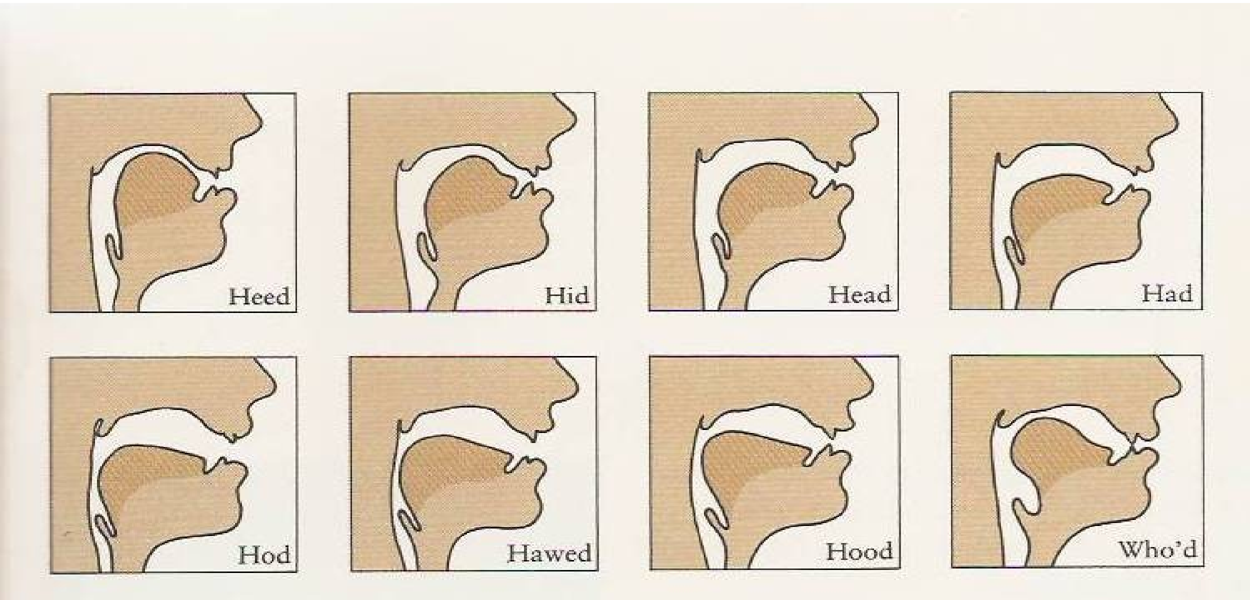
> The vowel sound 'oo'
> This vowel is a 'throat opener'. Forming it, directly exercises certain muscles from the muscular net in which the larynx is suspended... The vowel sound *oo*

exercises the principle to which the term 'covering' has been given; the voice acquires a 'head tone' quality.
The vowel sound 'ee'
Practising this vowel sound exercises the stretchers (Crico-thyroid and Posticus) and the Closers (lateralis and transversus). The Tensors (the entire vocalis system) are slightly, possibly wholly relaxed... If properly handled it is a useful vowel for finding and strengthening the falsetto...

The vowel sound 'ah'
This vowel sound belongs to the Tensors i.e., the vocal lips themselves (vocalis system). It serves to rouse the main muscular body of the vocal folds as well as their marginal muscle-fibres
(F. Husler and Y. Rodd-Marling, 1976 p.98)

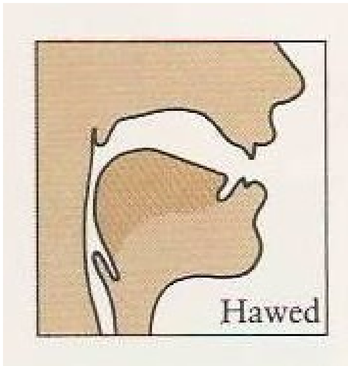
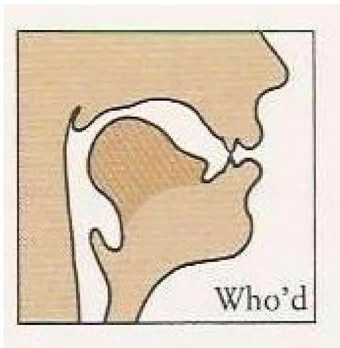
This final point serves to explain why the 'ah' vowel sound, often described as an 'open throat' position as mentioned in Rousseau (1987), is useful in good tone production. The engagement of the whole vocal fold system helps the saxophonist to develop a strong tone; however, with different vowels come from differing tongue positions as can be seen from the following diagram taken from *The Science of Musical Sound* (1983) by John R. Pierce:

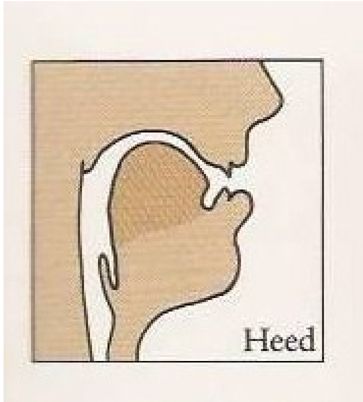
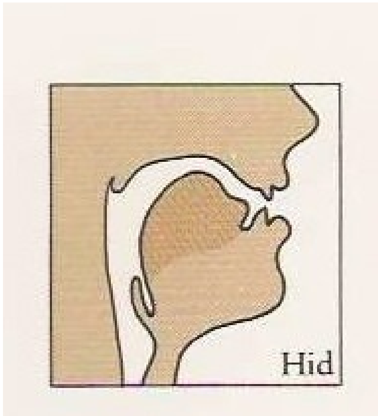
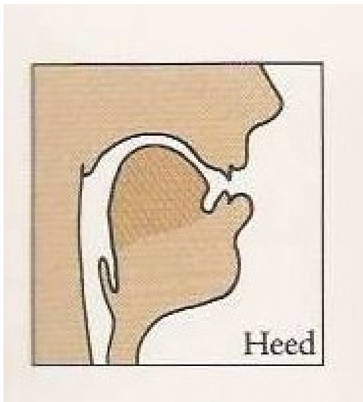
Fig.2.39 Diagram of tongue positions when pronouncing different vowel shapes

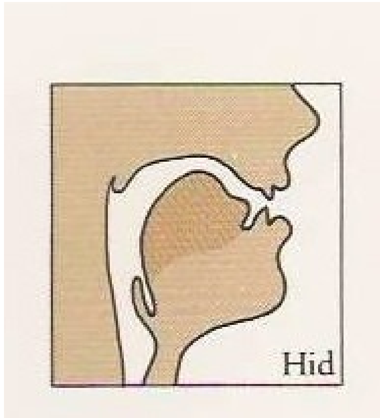
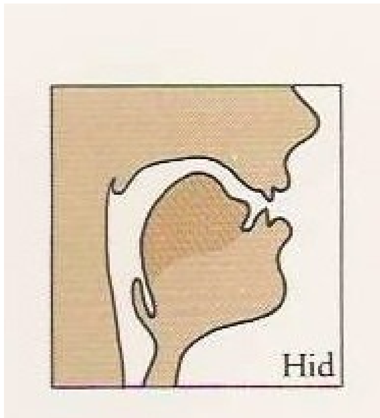


Here the tongue is low in the mouth with the vowels 'Had' and 'Hawed' allowing the vocal folds to resonate fully on the 'ah' vowel. Other vowels, especially 'Heed' and 'Hid' bring the tongue forward and high in the mouth, facilitating a higher velocity in the air stream which is consistent with Bernouilli's principle. These are the vowel shapes a saxophonist uses in order to place the tongue in the correct position to play the harmonic series. Vowel shapes are also very useful when playing individual partials within a multiphonic as each position roughly relates to a specific partial in the harmonic series. In order to demonstrate this I have recorded a complete harmonic series on soprano saxophone and I have specified a vowel shape for the fundamental and each subsequent partial. Without the benefit of x-ray or videofluorographic technology I can only use the 'feeling' of each vowel shape as my point of reference, and indeed other players' perception of these shapes could well differ from my own. I have recorded these tongue positions starting on a written Bb3 on the soprano saxophone (track 43).

Table 9: Diagram of the harmonic series played on the soprano saxophone and the corresponding tongue positions

Fundamental	
First partial	

Second partial	
Third partial	
Fourth partial	

Fifth partial	
Sixth partial	

The difference between the fifth and sixth partials is very subtle and so one position 'Hid' is indicated whereas in practice the saxophonist is constantly using their ear to 'sing' the note as they play it which ensures the correct tongue position is reached.

Although vowel shapes cannot hope to cover every partial possible on the instrument they are a useful tool for a performer to utilise as they prepare extended techniques for performance. As before the performer can exploit the tongue position in order to emphasise pitch relationships within a multiphonic, or to regulate intonation when playing micro-tones, or hit specific pitches within a harmonic series, depending upon the demands of the piece. By using tongue positions and embouchure manipulations performers not only control an extended technique but also highlight the role of the technique within the composition by emphasising pitch relationships; microtonal tunings; and by emphasising beating patterns using either the tongue in the case of multiphonics or through use of the voice to alter the heterodyne relationships within multiple sounds. Understanding the acoustical behaviour of their instrument enables the performer to alter either mechanical (fork fingerings and ventings) or physiological (tongue and embouchure) preparations in order to present an accurate and nuanced extended technique which serves the composition as a whole.

Chapter 3

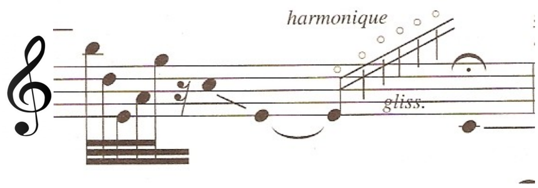
The Preparation and Performance of Extended Techniques Within Notated Music

Previously I have shown that choice of instrument, mouthpiece, reed, tongue position and the control of air through the larynx all have a bearing on the sound which is created whilst performing extended techniques. The relationship between the performer's understanding of this physical dexterity within the oral cavity and the sound they wish to produce highlights the importance of choice in the interpretation of these techniques. This interpretation begins with the choice of sound a performer wishes to produce, and also in considering why that particular sound is preferable when considering the thematic material that surrounds it. This is dependant on the type of physical production technique needed in order to create the appropriate sound, which demands a level of physical dexterity on the part of the performer to decide: which sound is appropriate; how that sound is produced; and what can be done to manipulate the parameters of an extended technique to further enhance its meaning within the composition as a whole. Performers have different understandings of how extended techniques work, and therefore of the physical method of sound production needed to attain them. As the pedagogy in this area is limited to a few texts (as has been discussed in chapter 1) it is largely left to the performer's discretion as to how each technique should be approached within a composition. When experiencing performances of works which include extended techniques it is interesting to note how different performers achieve different sounds when performing these techniques, therefore posing questions as to the approach to their methods of sound production.

An Exploration Into the Variation of Sounds in the Performance of Extended Techniques.

A piece which has firmly established itself in the saxophone canon is Yoshimatsu's *Fuzzy Bird Sonata (1995)* which receives performances from a wide variety of players, from students to recording artists. The first movement of the sonata includes two different extended techniques: a harmonic ascending *glissando* from the fundamental E4 (figure 3.1) and later in the movement a passage of slap-tonguing mixed with normal pitches (figure 3.2). It is interesting to hear how each performer approaches the production of the techniques involved. The piece was composed for the Japanese saxophonist Noboya Sugawa who released the work on his album *Fuzzy Bird* (1991), and in this version the harmonic *glissando* is produced by pitching the first partial of E4 and then using the tongue to carry on the *glissando* by moving it back and upwards toward the hard palate thus creating the necessary velocity of air needed to move through the remaining partials (track 44). Sugawa finishes roughly around B6 which is the fifth partial of the low E fundamental, perhaps lending his *glissando* a pleasing tonic-dominant effect. It is interesting to note that Yoshimatsu has notated six 'harmoniques' in the score (including the fundamental as number one) which could possibly explain Sugawa's decision to stop at

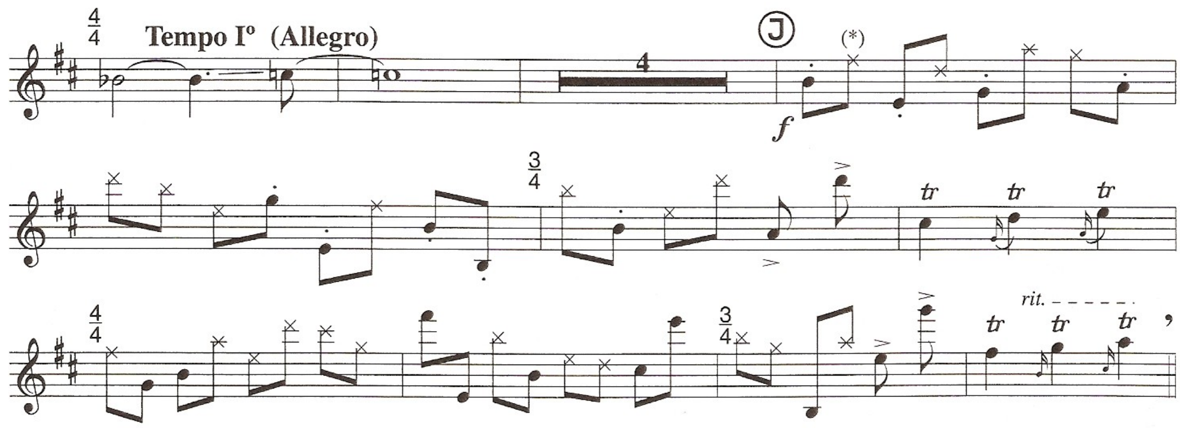
Fig.3.1 Yoshimatsu *Fuzzy Bird Sonata* (1991) Mvmt 1 figure B



partial number five. On Rob Buckland's album *Towards the Light (2009)* he approaches this technique in a similar way to Sugawa; however, before he reaches the first partial there is a subtle use of regular fingering mixed with tongue movement beginning the *glissando* much lower in the register than would be possible if using only the partials of E4 (track 45). Buckland finishes his *glissando* much higher in the saxophone's register ending at around F – F#7 which equates to the eighth partial of the fundamental. The most recent release of the Fuzzy Bird Sonata by Sarah Markham on the album *Sing, Run, Fly (2011)* reveals a third interpretation of this technique; Markham's *glissando* is much shorter in duration than either Sugawa or Buckland's as Markham begins her glissando on the sixth partial and uses her tongue to move through partial seven to stop on partial eight (track 46).

The differences between these three performers' interpretation of extended techniques is further highlighted by the passage of slap-tonguing towards the middle of the movement as shown in Figure 3.2. When listening to Sugawa's version the percussive effect of the slap-tongue is clearly audible throughout the saxophone's range. Sugawa cleanly moves between the curled tongue position required for slap-tonguing and normal tongue shape which

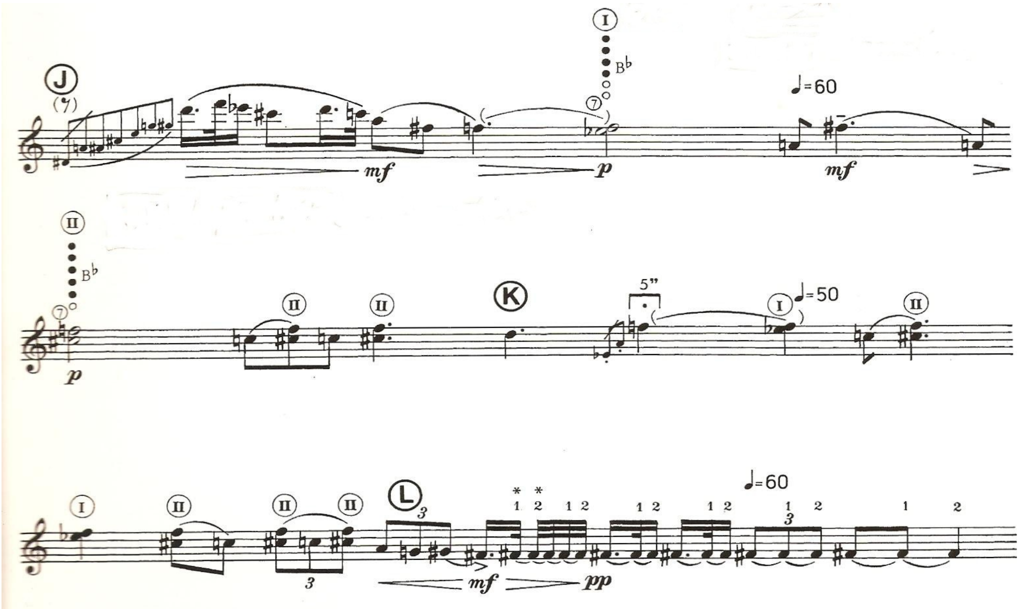
Fig.3.2 Yoshimatsu *Fuzzy Bird Sonata* (1991) Mvmt 1 figure J



places the tongue further back in the oral cavity, achieving a seamless transition between the two styles (track 47). If we again compare the recordings of Buckland and Markham we find that both saxophonists fail to produce a significant percussive effect whilst interpreting this slap-tongue notation, instead playing the noted 'x's' very lightly as if employing the jazz (associated) technique of 'ghosting' the notes (Buckland's version is track 48 and Markham's is track 49). This large difference between recorded versions of the piece, and indeed the sounds produced, pose questions regarding the performance and interpretation of extended techniques in performance: what is the composer's intention for this technique?; what is the contextual role of the technique within this composition?; what physical manipulations and abilities are required in order to achieve these sounds?

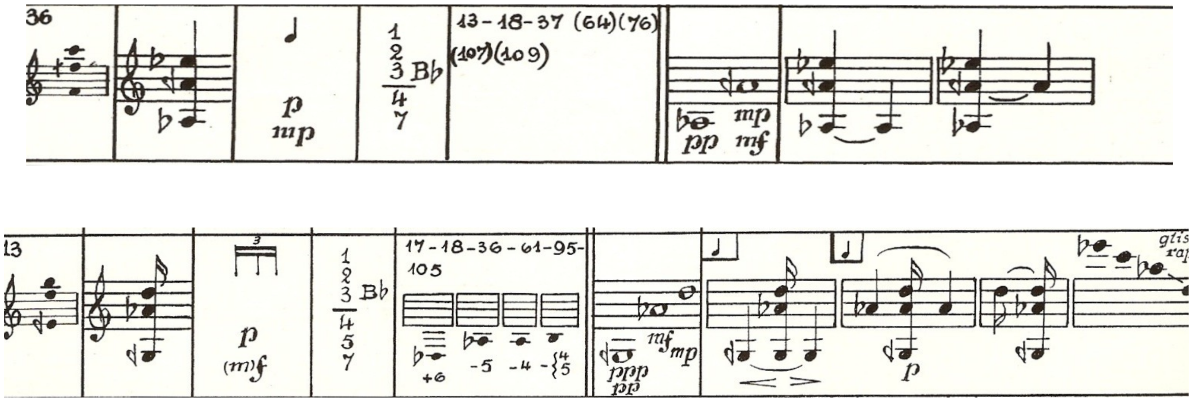
More subtle variations in sound can usually be heard whilst performing multiphonics due to the nature of their acoustic makeup as they are generally produced by multiple harmonic series' (resulting from two or more sinusoids being present) sounded simultaneously. This tonal variance can be controlled with greater or lesser accuracy depending on the type of multiphonic being performed; type B multiphonics (see Chapter 1) are usually easy to manipulate due to their widely spaced partials whereas type E dyads are very closely spaced and thus the opportunity for control is diminished. If we consider the multiphonics used in *Berio's Sequenza IXb* (1980, figure 3.3) it would seem from their narrow dyad sound that these multiphonics do not have much variance within them for the performer to manipulate.

Fig.3.3 Luciano Berio *Sequenza Ixb* (1980) figure J



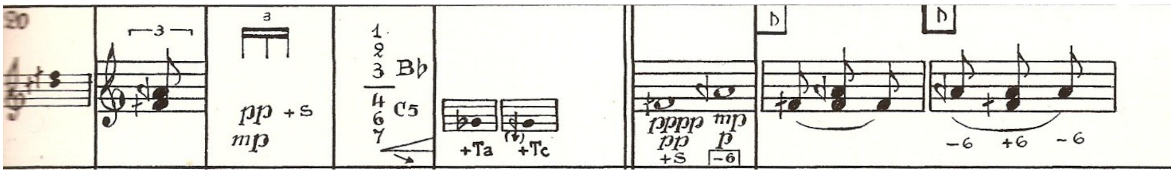
On the other hand, by consulting Kientzy's book *Les Sons Multiples Aux Saxophones* (2003) it can be seen that the fingerings that are given correspond with multiphonics that are not in fact type Eb dyads but are type A which make them an octave plus a twelfth. This means that in performances of this work following the fingering given in the score the performer has to manipulate these two multiphonics to suppress the unwanted partials. The first multiphonic corresponds to Kientzy number 36 and the second to Kientzy number 13 as shown in figure 3.4. Both of these multiphonics have low partials sounding beneath the strongest sounding partials which need to be suppressed if the illusion of a dyad is to be achieved. An example of this suppression can be heard on tracks 50 and 51, where I have recorded Kientzy multiphonic numbers 36 and 13 respectively.

Fig.3.4 Kientzy multiphonic numbers 36 and 13 as taken from *Les Sons Multiples Aux Saxophones* (2003)



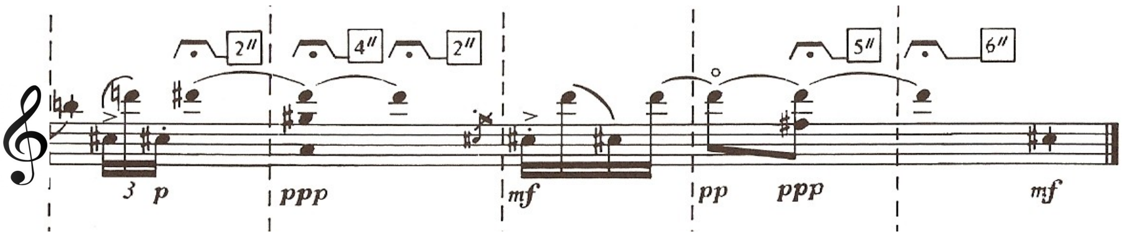
Whilst listening to two different recordings of the work it is evident that these multiphonics are being used in both cases, with the performer manipulating the mulitphonics in slightly different ways. In the first recording taken from Claude Delangle's *The solitary Saxophone* (1994) Delangle manages to suppress the partial sounding at C6 of Kientzy multiphonic number 36, giving a dyad in which the F5 is sounded but the Eb5 is an octave lower as can be heard on track 52. This is done by tuning the vocal tract so that it reSonata s with the F5 ensuring that the higher C6 does not sound. By contrast Wallace Halliday's recording of the same piece taken from *Berio – Sequenzas I-XIV* (2006, track 53) Halliday sounds the Eb as the strongest partial of his first multiphonic, losing strength in the sustained F5 but at the same time pitching both pitches in the correct octave. As the pitch Eb4 does not appear in Kientzy number 36 it is my suspicion that Halliday has chosen another multiphonic which includes the two pitches, perhaps Kientzy number 20 as shown in figure 3.5 (track 54), in order to keep the thematic material in tact. The second multiphonic is suppressed in much the same manner as Delangle achieves, generating the desired dyad. More elements of physical manipulation are evident when listening to both Delangle and Halliday's versions of *Sequenza VIIb (1995)* on the same recordings during which the listener can hear

Fig.3.5 Kientzy multiphonic number 20 as taken from *Les Sons Multiples Aux Saxophones* (2003)



differences in the sounds of the multiphonics produced toward the end of the piece as shown in figure 3.6. This feature is generated by switching between fingerings for the upper partials and fingerings for the multiphonics themselves, creating a sustained tone with a

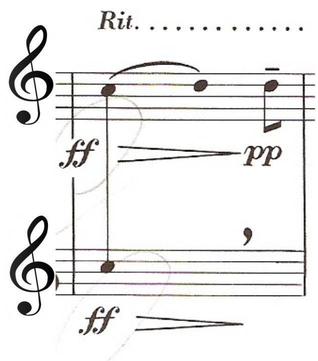
Fig.3.6 Luciano Berio *Sequenza VIIb* (2003) line 13



multiphonic which appears beneath it. In Delangle's version (track 55) he manages to sustain the D#6 throughout the gesture as Berio notates in the score; however, in Halliday's version (track 56) the lower fundamentals of the multiphonic are much stronger and block out the sustained note which is also slightly de-tuned. The reason for this could be due to one of two things; it could be that with an incorrect tongue position and vocal tract tuning Halliday is not able to pitch and sustain the D#3 or that his saxophone and mouthpiece combination simply does not produce the partials in the same way that Delangle's does for that specific multiphonic fingering. It has already been mentioned in the introduction to this thesis how Berio himself acknowledged the unreliability of multiphonic intervals, and indeed Redgate explains how recent versions of the score for *Sequenza VII* for oboe have been altered to accommodate microtonal intervals which are the resulting sound from these techniques (Redgate, 2007). The composer's acknowledgement of the variability of these intervals is significant as it gives the performer the chance to decide for himself which pitch relationships in the multiphonic are important to the piece. In Philip Thomas's article entitled *Berio Sequenza IV: Approaches to Performance and Interpretation* (2007) Thomas discusses tonality in Berio's music, noting that Berio himself saw the *Sequenzas* as a logical extension of the classical tradition, rather than a rebellion against it (Thomas, 2007 p.195). Thomas goes on to state that 'it follows that at least some of the melodic material will have a degree of tonal pull' (Thomas, 2007 p.196), and this is evident when listening to each recording of *Sequenza VIIb* where both performers have chosen different intervals to accentuate with Delangle choosing the sustaining D5 over the lower intervals to create a sustained line, and Halliday preferring to highlight the intervals in the multiphonic.

Tuning the vocal tract is a technique which performers use to control many of these techniques as the vocal tract and larynx pairing is important in controlling the air as it enters the instrument. In Betsy Jolas' piece *Épisode Quatrième* (1983) the player is required to use the voice alongside the saxophone's sounding pitch to create the harmony shown in figure 3.7. The composer uses a double stave to indicate this harmony, the lower of which is the vocal part with the saxophone's line above. It is usual for the saxophonist to assume

Fig.3.7 Betsy Jolas *Épisode Quatrième* (1983) page 4 line 5



that the vocal part is transposed to the saxophone's pitch in order for the instrumentalist to pitch their notes from their instrument. In the case of *Épisode Quatrième* both pitches begin in unison on C5; however, the voice remains static as the saxophone's pitch rises. Claude Delangle's version of *Épisode Quatrième* from his album *The Solitary Saxophone (1994)* includes a very strong vocal part so as to be heard over the saxophone and thus the interval of a major second is very clear as the saxophone ascends as can be heard on track 57. In

Daniel Kientzy's version from his album *Saxophone(s) Solo* (1984, track 58) the listener can hear a slightly weaker vocal part which seems to sweep upwards pre-empting the saxophone's movement, this therefore makes the specific interval of a major second unclear. Similarly when the technique of singing and playing is repeated later in the piece Delangle's version pitches the vocal part sharp from an A4 to an A4 three quarter-tones sharp, which results in the creation of complex beating patterns against the following B4 whilst not quite remaining faithful to the score. It is indeed possible that each performer aims for the given pitch and has simply over or under pitched their note during the recording session, or it could also be their intention to emphasise the effect the voice has on the saxophone's tone, once again posing the question, 'which of the relationships in this piece are to be emphasized, to be made explicit?' (Cone, 1968, p.34).

Performers' Perspectives of Interpreting Extended Techniques.

Based upon what has already been discussed in previous chapters the practical use of extended techniques in live performance poses some questions such as: what purpose does the technique serve in the piece as a whole? How do I need to alter my normal technique in order to make the extended technique sound in the way I want it to? How is my choice of instrument and mouthpiece/ligature/reed set up going to affect the resultant sound? When interviewing performers who use extended techniques in either notated compositions or in improvised music it is found that much common ground is shared in answer to these questions. To highlight this common ground and to begin a discussion pertaining to the above questions I have interviewed seven saxophonists, five readers of notated music and two improvisers. The saxophonists who are represented in the following discussion are Evan Parker, Rob Buckland, John Butcher, Frank Gratkowski, Simon Haram, John Harle, Franziska Schroeder, and Andy Scott.

The Relationship Between Equipment Choice and the Resultant Sound

The improviser John Butcher asserts that 'if you stood four different players in a room and said “play this multiphonic” you'd get four different sounds.' We have already seen in the chapter on acoustics how different equipment alters the resultant sound of the saxophone and the extended technique being articulated. Butcher goes on to say that he plays a specific mouthpiece with a specific saxophone in order to achieve a specific sound. This idea is echoed by Rob Buckland, who makes the differentiation between 'classical' and 'jazz' mouthpiece functions as follows:

> Jazz equipment... the responsibility of the individual to superimpose a sound on [jazz equipment] is much smaller... the mouthpiece does most of the work. Whereas [classical players] play on a C* or an AL3 on a Selmer type saxophone we all sound different: because it's so closed we have to open up behind it therefore the superimposition is greater [due to] our own vocality and resonance.

Indeed Buckland goes even further into this idea behind the relationship between the superimposition of an individual player and the sounds they produce by considering the following point:

> I'm six-foot-one-and-a-bit maybe the way this [saxophone] plays the [resultant] resistance that [it] generates suits my build. I have a student who's five foot two, maybe they don't generate the same air stream so that doesn't balance the same way they like it.

This further highlights the importance of the relationship between player, instrument and mouthpiece and reed setup due to individual physiology. When asked how important the relationship between equipment choice and extended technique is, internationally renowned soloist John Harle replied:

> Not very. Obviously some set-ups prohibit extended techniques because of either reed inflexibility or mouthpiece chamber shape, but most players have difficulty with extended techniques because of very poor air support and unnaturally high levels of muscular tension constricting the reed, airflow and resonance within the oral chamber.

This indicates that although there is a relationship between equipment choice and the resultant sounds, the air support and internal manipulation is far more important when playing these techniques. Buckland supports the theory that some mouthpieces hinder reed flexibility by stating that when his students 'play one of these Christian Lauba things they have to play that on a “soft” setup otherwise the multiphonics or the slap tongue doesn't work'. Buckland here is making the point that although this 'soft' setup is useful for an extended technique-heavy piece such as Lauba's works, the tone this creates may not be suitable for other works in the saxophone canon.

Andy Scott also stresses the importance of the correct mouthpiece setup as follows:

> the mouthpiece and reed set up will enable you to execute extended techniques, but won't do it for you! The reed mustn't close up onto the mouthpiece - so the balance between reed strength and opening of mouthpiece is vital, this is where the performer needs experience to really understand this situation. So, when the muscular pressure of the embouchure is in use, the air must be able to go into the instrument freely. The key, is flexibility of the throat/tongue/larynx, coupled with control and manipulation of the airflow/support.

Finding a compromise between tone and flexibility in equipment set up is mentioned by both Dr. Franziska Schroeder and soloist Simon Haram, both of whom do not change their mouthpiece setup to aid extended techniques. Haram explains:

> I don't change my set up to play special effects. if I can't get them with a "proper" set up I get as near as possible and leave it at that. If the composer wants something extraordinary and leaves time to change mouthpiece for example that's fine but normally these effects come thick and fast in amongst regular playing and I don't like to compromise things for the sake of a "trick".

The compromise between practicality and ease of manipulation appears to be important to each performer due to the need to be flexible in their playing approach and indeed in their repertoire choice.

The Balance Between Established and Extended Saxophone Technique

Alongside the choice of equipment for those who perform extended techniques lies their own personal philosophy about general playing technique, all of which has a bearing on the sounds they expect to produce within a composition. Again on this topic (and perhaps unsurprisingly) there are large areas of common ground, with some slight deviations depending on the individual's understanding. John Harle notes that he himself does not use what is thought of as the standard breathing technique in that he has developed a technique of vocal fold manipulation pressurised from the lungs using clavicular breathing (possibly a mixture of 'high' and 'low' breaths as described in the previous chapter). He explains:

> The air I use is highly pressurised from the lungs, and the embouchure is to all intents and purposes 'passive' and very relaxed. Vocal fold training and exercise is as important as larynx or oral cavity manipulation, and certainly more reliable.

Here we have another confirmation that it is what happens inside the player's body that effects what happens to the saxophone itself.

Buckland has the theory that the tongue inside the saxophonist's oral cavity is completing a 'virtual cone' inside the oral cavity; by which he means that the pressure created by the proximity of the tongue to the soft palate is similar to the point at which the saxophone's parabolic curve would have come to an end were it to continue to a point. To demonstrate this he surmised that when playing an altissimo D7 on the alto's crook the fingers do not need to do anything as the crook is tuned to F4 and therefore the D is the fifth partial of that F according to the harmonic series. After demonstrating this successfully he went on to describe how tongue position also affects different sizes of saxophone:

> I think that the position your tongue goes in... on lets say a high C on the alto is in the same position as if I was to play a high F on the soprano, which is the same as a super F on the tenor... a top Bb on the soprano is the same as a super G on the alto.

Buckland expands this point by discussing how we 'learn by listening' in order to successfully produce the whole range of harmonics, that is to say that the correlation between the control and dexterity needed within the oral cavity and the desired sound can only be learned through muscle memory as each player is different. Buckland uses the analogy 'it's like listening to sculpture' in that in abstract the two things are entirely different yet we as performers are attempting to achieve a certain sound from a seemingly (as far as normal playing technique goes) unrelated part of our physiology. Some of the performers interviewed mentioned the importance of singing in relation to the production of successful harmonics when preparing extended techniques, backing up the study seen in the previous chapter which concluded that saxophonists learn to tune their vocal tract

(Chen, Smith, Wolfe, 2008). Frank Gratkowski put the most importance on this demonstrating how he vocalises everything he plays (not just extended techniques) in order to learn the harmonic language of a piece. Berlin-based improviser and composer Frank Gratkowski also believes in the use of an individuals' vocal tract to play not only extended techniques but also for regular playing, adding the point that the player must allow the instrument to do the work: a point he learned through his studies with the late jazz legend Steve Lacy who would tell him 'you have to follow the instrument, not play the right harmonics'.

With this point in mind then it stands to reason how each different performer may produce a different sound whilst playing the same multiphonic or harmonic. Gratkowski takes issue with the conclusion of a paper by Chen et al noting that 'I can't sing so high!'. This comment raises the point that saxophonists being both male and female and also being expected to play all sizes of the instrument cannot possibly cover the entire range vocally, and therefore this tuning of the vocal tract must be approximate and not necessarily at the correct octave in order to be effective. Simon Haram discussed a technique-specific approach to extended techniques by noting that:

> multiphonics tend to be all slightly different and so some work better top down and vice versa. I don't have a one size fits all approach. 1/4 tones are also a mixed bag, some working very successfully and some either very impractical or impossible. Some are available by good finger combinations and some are cludges achieved by compromising the embouchure.

The observation that some multiphonics work best sounding the lowest or the highest partial first is a common experience for most saxophonists, as the physiology needed to manipulate each multiphonic fully is so specific as to be impossible to learn for each of the 180 multiphonics for alto alone.

Performers' Perspective on Composers' Use of Extended Techniques

The employment of extended techniques within compositions is a divisive issue between the different performers. Andy Scott describes his approach to the use of extended techniques within a composition thus:

> It's how intelligently the composer has used these techniques that is of interest to me. Generally I see them as colours, and colours only, they have to fit within an overall form and shape of a piece to be effective. I've heard pieces of music that consist entirely of colours, which unfortunately doesn't have any emotional impact with the listener and shape/direction.

Andy Scott makes reference to an improvisation he recorded for his CD *Xilitia-Stairway to the Stars* (2010) which uses multiphonics as tone colours:

> Extended techniques do add colour, and if used wisely are extremely effective. I use them in improvised music... One track is solo sax multiphonics - I chose specific multiphonics that would create tension and release, both dynamically and harmonically, and overall that would create a shape and feeling of journey.

This approach seems common to improvisers who need to use extended techniques as compositional tools but not necessarily as harmonic language, which has been seen previously in John Coltrane's work and also in the thesis *A Thesaurus of Saxophone Multiphonics and a Guide to their Practical Application* (Phelps,1998). The idea that a composition can reflect a zeal for over-using extended techniques is also referred to by Simon Haram who reveals:

> I personally don't enjoy pieces that look like the composer has discovered "101 mad things to do with a saxophone part 2" and just tried as hard as possible to squeeze them all in. Many young composers I have worked with seem absolutely fascinated with extended techniques and are desperate to use them all the time. This seems the wrong way round to me as they often haven't got much to say with regular notes yet and extended stuff often feels like they're running before they can walk!

It seems that the performers prefer to experience 'intelligent' use of extended techniques, principally regarding the techniques as 'a natural form of expression in the palette of colours available on the instrument' (John Harle) rather than as solid compositional material. Indeed Rob Buckland points out some problems he experienced with a composer who wished to use multiphonics in order to build up harmonic material in a saxophone quartet:

> there must be fifty of these [multiphonics] in a row, and you meet up for rehearsal and he says “well, they were just suggestions but if you know any others you can play those”. So you've been struggling for hours with those that don't make a noise and you play him something else he goes “yeah that's

great”. So it's composer-specific.

On the other hand Frank Gratkowski describes how he wished to use specific multiphonics in one of his own compositions for multiple players, however, he came across a problem to do with equipment:

> [on] that [saxophone] it works but it's much more difficult. So I try to find ones but then... when I use them in a composition I definitely want people to find something close... I had a mark VI when I wrote it then I couldn't play the piece anymore as long as I played that thing [pointing to his Selmer reference 54]. So it's impossible... I just wrote a piece for alto saxophones only multiphonics... one had to really redefine the whole thing. I said: find similar horns because [the player] had the old Martin horn which was totally different. So you know he needed different fingerings. And the other two guys had a mark VI and even on a mark VI it sounds a little bit different to this one [Reference 54].

Gratkowski is here confirming how using different equipment can drastically alter the sound produced when using multiphonics and harmonics. Some mulitphonics are more stable than others and Buckland notes that:

> whereas the Lauba ones... because they're written by a saxophone player that's the only option and they work really well. Because he knows what he's doing.

Buckland is asserting here that when performing a piece composed of familiar, stable multiphonics that are easy to control, the margin for sonic difference is smaller than when playing un-stable multiphonics that are easily changeable due to tongue and throat placement.

The Need for Collaboration

Rob Buckland notes how many composers have in the past over-used extended techniques within compositions without giving thought as to the dexterity needed during the performance of the work:

> composers fall into that trap where they hear a saxophonist doing something like this and its all very exciting... so then they go for the Kientzy book and they have a look and find out what the ones that work are, most people use the same three or four anyway. They write it in the music... then they leave that up to interpretation. Of course most... non-saxophone players don't have

> the understanding of how they're generated and so therefore they're normally swayed by a big personality saying “I'm going to do it like this!”.

Many of the performers interviewed agreed that books like Kientzy's *Les Sons Multiples Aux Saxophones (2003)*, and Weiss & Netti's *The Art of Saxophone Playing (2010)* which include tables of extended multiphonic and monophonic possibilities often forget that the production of such techniques relies heavily on not only the fingers, but as we have seen in previous chapters the large amount of vocal, laryngeal and tongue dexterity needed for their successful production and manipulation. Simon Haram mentions that:

> I tend to try and work out what effect that composer is trying to create and try to find something that fits the bill

an approach which seems to leave the performer guessing as to the composer's intention. John Butcher shows a certain amount of discomfort with composers taking ownership of extended techniques away from performers, making the point that most of these techniques hail from world music which is largely taught through aural traditions:

> People have been playing these techniques and making these sounds for hundreds of years through music that has been passed down through tradition. It is only recently that people have begun to start attempting to notate these sounds that already exist. In a way the composers are only just catching up with the performers.

Butcher is outlining the idea that music learned in this way is in contrast to notated music having different histories and traditions surrounding them. Music that is learned through tradition engages the player in learning different aspects of an instrument and its sounds, whereas notated music explores a composer's use of harmony and thematic material but not necessarily, in the case of solo pieces, a performer's individual style and timbre. It is because of the ownership that instrumentalists have over their own sound-production techniques that performers prefer a collaborative approach which allows them to guide a composer towards techniques that can be successfully employed based on the ability of the performer who will play them. This is of particular importance when considering an approach to notation when writing the score which is, as Rob Buckland puts it, 'an inexact representation' of the sound to be presented, effectively outlining the paradox that Butcher presents us with of attempting to turn a two-dimensional graphical symbol into a three dimensional sound. Buckland continues to describe how composers, preferring textbooks to performer's advice, can be problematic to the very physiological phenomena they are trying to harness:

> the recall is just so demanding to remember... that's the fingering, I need to think that note there, put my tongue in that position and play there... you have to change so many things so quickly. This is what what composers forget.

Franziska Schroeder prefers to collaborate with composers from her institution so that she can be on hand to offer suggestions as to the use of techniques that are familiar to her. She mentioned that 'I think most players have a list of multiphonics that they know and use often', indeed this is backed up by both Gratkowski and Butcher who both recommended creating a list of the multiphonics one knows and adding to that list every time you learn a new one. There appears to be a divide between those who improvise (Butcher, Gratkowski, Schroeder) and those who often play notated music (Buckland, Harle, Haram) as to the merits of learning extended techniques like multiphonics by heart as the latter players seem to rely on the score to inform them what to do, therefore do not have such a need for memorization.

The Composer's Perception About the Interpretation of Extended Techniques Within Their Own Compositions.

During the course of researching information for this thesis I have been able to collaborate with composers who were eager to learn about extended techniques and to compose pieces based around these techniques. In conversation with these composers it is evident that although each of their compositional styles are different, their emphasis on a performer's understanding of their musical style, philosophy, and musical principles was important in each composer entrusting a performer with their composition. Ben Isaacs makes a direct link between extended techniques on the saxophone and the style he wishes to portray in his music, stating that:

> the aim when adopting such techniques is to create a volatile and dynamic performance situation in which the tactility of the sound and 'live-ness' of the performer's action is an integral part of the musical experience.

Isaacs uses this in his piece *I Never Look Like Myself* (2010) by using extreme dynamics so that his ascending microtones are barely heard, existing mostly within the *niente* dynamic marking. Likewise, composer Ray Evanoff states that his use of extended techniques in *Diagramming a Vivisection of Yours and Mine (Ineffectual Tracings of Antiquated Sounds): A Floregium* (2010) is a result of 'a desire to instil my musical language born from timbral variety, and a concern with the tactile aspects of instrumental execution.' In both cases the composer is making reference to their goal of exploiting the transient nature of performance, and of performing extended techniques, in order to promote a sound which is, as Evanoff puts it, on the 'knife-edge of feasibility'. Evanoff does not wish to push his performers into the realm of impracticality and mentions that 'crass neglect of an instrument's inherent nature undermines the music's reliability', further noting that 'ideally, a performer will trust that these techniques' impracticalities serve a greater purpose'.

A composer who writes music with a higher level of specificity is Scott Mc Laughlin whose piece *Neither Wholes nor Parts* (2010) uses a graphical key as a score which acts as a 'mechanism' by which the music is made. Based solely around linking different multiphonics through pitching single partials within them, Mc Laughlin explains how the written score cannot exist without the performance directions to decipher the symbols. He states 'within symbols there is a certain amount of flexibility within a graphical context', meaning that his score blurs the line between what a performer sees written on the score and what sounds are heard as the performer is free to choose the multiphonics that fit into the work the best. When asked about the performer's relationship and learning curve with a new notational system, Mc Laughlin points out that the score is not the point:

> The point is those tipping points [between two sounds]... the point is the [enharmonics] and getting out those multiphonic partials. Once someone understands and accepts that then the [symbolism in the score] is pretty clear.

Mc Laughlin believes that 'once someone accepts that that's a viable way to create a piece of music then the notation works', indicating that the performer's understanding of the score, in the case of Mc Laughlin's work, transcends the score itself.

By understanding the composer's intentions in using extended techniques within their compositions, the performer can make decisions as to how to approach the production of the techniques based upon this understanding. Delangle and Michat explain how this acceptance of different styles based around the saxophone are an important part of its continuing heritage:

> Nineteenth-century saxophone music is virtually non-existent, the student has hardly known the type of repertoire in which the fingers trust the ear. Instead, he is brought up from the start in an atonal, often extremely chromatic, language.
>
> (Delangle & Michat, 1998 p.161)

The composers represented here are simply expanding musical language and therefore instrumental technique and saxophonists are well placed to develop their instrument's technique to advance it to the level of the orchestral woodwinds.

Chapter 4

Preparing Extended Techniques for the Saxophone: 7 Case Studies

An outline of extended technique usage has been given in the previous chapter but hitherto no suggestions as to a performance method have been put forward. In this next section I hope to demonstrate the relationship between the desired sound in the context of the musical passage, the physical manipulation of the extended technique, and a knowledge of the techniques and their acoustical behaviour, in order to present a working and demonstrable method for performance. For the sake of clarity and structure I will present my approach to these techniques in the same order as they were presented in chapter one. Table 10 again shows the categories of extended techniques as derived from both Londeix, (1989) and Weiss & Netti (2010), and through use of this classification I shall discuss the techniques within each composition, and present ideas toward the performance of them including the reasons for those decisions.

Table 10: Classifications of extended techniques as compiled as a combination of Weiss & Netti (2010) and Londeix's (1989) suggestions

Pitch	Altissimo Harmonics (Aeolian Sounds) Mictrotones
Multiphonics	Singing and playing Multiphonics
Timbre techniques	Timbral fingerings (Bisbigliando) Embouchures techniques Key percussion Flutter tongue
Duration techniques	Slap tongue (short duration) Circular breathing (long duration)

This chapter is presented in two halves: the first half (sections 1, 2, 3, and 4) are case studies of published pieces which feature in the saxophone's standard repertoire. Betsy Jolas's *Épisode Quatrième* (1983) for tenor saxophone and Nicolaus A. Huber's *Aus Schmerz und Trauer* for alto saxophone have both found their way into the standard repertoire for concert saxophonists. Fuminori Tanada's *Mysterious Morning III* (1996) for soprano saxophone and Ichirô Nodaïra's *Arabesque III* (1983) for alto saxophone and piano were both commissioned by Claude Delangle and appear on his album entitled *The Japanese Saxophone* (1998). All four works display a mastery of extended techniques achieving, in the author's opinion, an integration of these extended techniques into the individual style of the composer.

The second half of this chapter (sections 5, 6, and 7) presents three works that were written for the author using a collaborative approach which was designed to retain the integrity of the composer's individual style whilst at the same time creating a work in which extended techniques are a feature. All three composers (Scott Mc Laughlin, Ben Isaacs and Ray Evanoff) worked together with the author to ascertain the level of flexibility within an extended technique in order to create a piece which showcases these nuances. This chapter documents my approach to each individual work using the above criteria of extended techniques, based upon my personal understanding of the important relationships within each composition.

Section 1

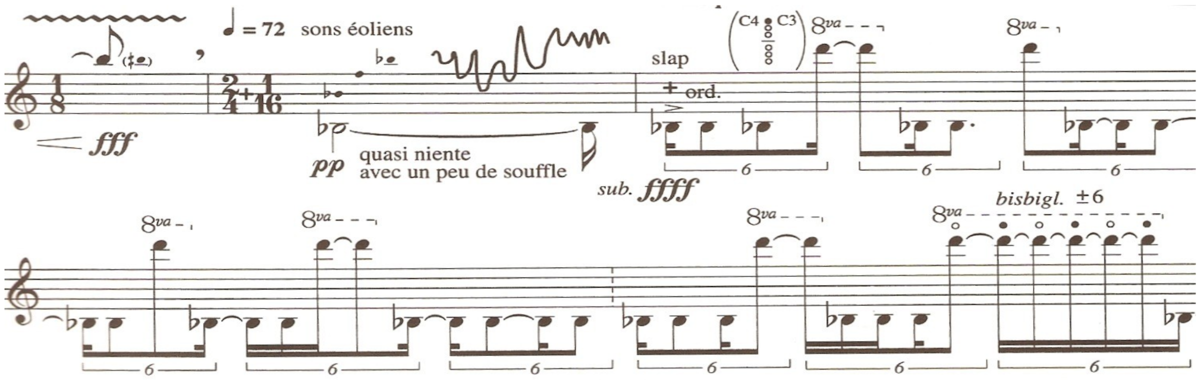
Fuminori Tanada *Mysterious Morning III* (1996) For Soprano Saxophone

The organisation of material in Fuminori Tanada's *Mysterious Morning III* (1996) offers the performer hints as to the employment of the extended techniques that are used throughout the piece. Tanada states in his performance directions that 'the piece should be played straight through without stopping (excepted for pauses for breath), giving the impression of a wild saxophonist nervously improvising, playing anxiously' and indeed there is evidence of this in the score, including breath marks that represent 'panting (breathe deeply but rapidly)' and the addition of '*avec souffle*' or air sound to hint at a saxophonist who is losing control over their embouchure allowing sound to escape. In the sleeve notes for Claude Delangle's recording *The Japanese Saxophone* (1998) Delangle quotes Tanada: 'in *Mysterious Morning III* I wished to create a state of sonic instability by means of extremely virtuoso writing, with various playing techniques such as *bisbigliato,* irregular trills, *glissandi,* sounds sung and played simultaneously, and micro-intervals; this instability is an image of a man quivering with madness, a madness that he attempts to conceal within himself; my wish was that the piece should sound like an improvisation' (Tanada in Delangle, 1998). The image of a saxophonist who is trying to keep control not only of the instrument but of themselves is an image which is also evident in the music as musical lines and themes deteriorate through the use of these various playing techniques in a score that often shows a repeated phrase which is treated differently each time it repeats through the addition of a 'sonic instability' brought about by an extended playing technique. In order to give 'the impression of a wild saxophonist nervously improvising' a performer can use the microtonal nature of cross-fingerings, multiphonics and the harmonic series in order to perform a piece that sounds spontaneous whilst at the same time exploiting relationships within the music with the purpose of presenting the illusion of an improvisation.

Altissimo

The extension of the saxophone's normal range in this piece is not a technique which is exploited; this is perhaps because this register on the soprano saxophone does not have the same impact as it does on the other sizes of saxophone due to its extremely short wavelength (upwards of 1396Hz) which can have the effect of being too shrill and therefore un-musical. This results in many composers neglecting the use of altissimo on the soprano saxophone as the common perception is, to quote saxophonist and composer Andy Scott: 'For me harmonics on the soprano sax just sound too high'. However, Tanada uses this perception to his advantage as his use of altissimo D7 is juxtaposed with the instrument's lowest note of Bb3, pitting the two extremes of the soprano saxophone's register against one another in the listener's ear as shown in figure 4.1.1. As the frequency of this note is so short it is difficult to exactly manipulate the vocal tract and tongue in order to pitch this note; the usual 'heed' tongue position results in the altissimo C7 (1864Hz) on the fingering given, and indeed other fingerings from Londeix (1989), Weiss & Netti (2010) and Rousseau (1978). In order to pitch the altissimo D7 (2093Hz) the player must bring the tongue not

Fig.4.1.1 Fuminori Tanada *Mysterious Morning III* (1996) page 6 lines 6 and 7

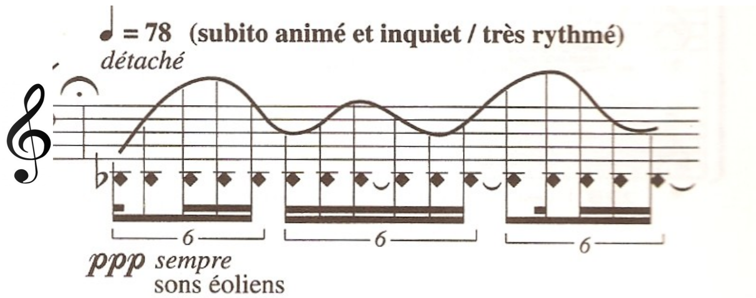


only into the 'heed' position but also all the way back toward the rear of the oral cavity; this makes the tongue expand across the back of the mouth and so raises it closer to the hard palate to achieve the air velocity necessary to produce the frequency . Rarely does a player adopt this extreme tongue position and it places some strain on the neck muscles and tendons which are employed to push the tongue into this position; it is therefore alien and uncomfortable to the player. Tanada's suggestion of the addition of the sixth finger to play a *bisbigliando* on this note (see figure 4.1.1) results in a satisfactory raise of frequency by approximately 2Hz (track 59). Because the frequency is so short another technique could be employed to reach the D7 and this is to lightly place the bottom teeth against the reed in an attempt to find the 'sweet spot' on the reed which will only allow a certain length of it to vibrate and thus create a higher frequency. This method is extremely inaccurate, however, and with this method the *bisbigliando* will not be effective as key venting does not work with pitches produced by the reed in this way.

Harmonics

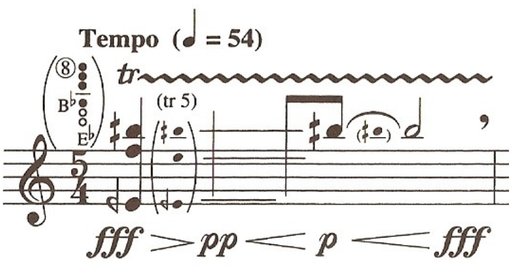
The specific usage of over-blown harmonics in this piece shows an understanding of the flexibility of the instrument in this range. As was explained in chapter 2 of this thesis the harmonic series can easily be sounded on a single fundamental through the adoption of the different tongue positions which concentrate the air stream in accordance with Bernouilli's principle. Tanada's stipulated *sons aeolians* (figure 4.1.2, track 24) is a reference to the

Fig.4.1.2 Fuminori Tanada *Mysterious Morning III* (1996) page 7 line 7



technique described in Londeix (1989) thus: 'The embouchure is not rigid, the lips are relaxed, the chin is pulled in, the lower jaw is well down, only the sound of air will be produced in the tone' (Londeix, 1989 p.81). This technique benefits from the use of throat and tongue positions to follow the contours of the rhythmic line that is stipulated in the score. Each time this technique is executed, the saxophonist can use the lower tongue positions of 'hood' and 'who'd' to help sound the lower partials moving to 'heed' and 'hid' for the higher partials in the usual way. A second use of harmonics in the work occurs on page six of the score based around a passage of multiphonic trills. On the fifth line of the page the composer includes a gesture during which the multiphonic trill *decrescendos* and then *crescendos* back to its original volume as the highest partial of the multiphonic sounding on its own as seen in figure 4.1.3.

Fig.4.1.3 Fuminori Tanada *Mysterious Morning III* (1996) page 6 line 5

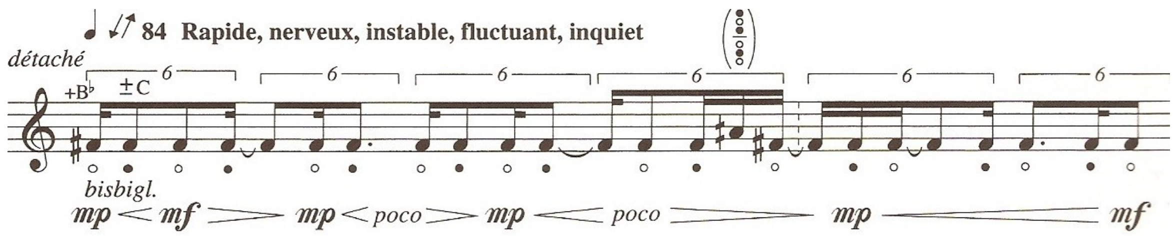


It is important here for the saxophonist to be fully aware of the tongue position needed to pitch the top note of the multiphonic each time, as it is the use of the tongue and throat position that will enable the single partial to be pitched. It is the 'heed' position which will accurately pitch the top note of the multiphonic allowing for it to be sounded independently, however, by maintaining this position for the timbre trill that follows (on the same fingering) the harmonic trill sounds at 990Hz (written C#6) trilling to 1050Hz (written D6). This is too sharp for the notated C6 a quartertone sharp *bisbigliando* trill and so adopting the less familiar 'who'd' tongue position pitches the top of the multiphonic but the relaxation of the lips into the 'who'd' shape flattens the note sufficiently (960Hz or written B5 quarter tone sharp trilling to 991Hz which equates to a written C5 quarter tone sharp) to differentiate this *bisbigliando* from the microtonal trills that feature elsewhere in the piece.

Microtones

Tanada uses microtones throughout the work to achieve the effect of a minutely descending melodic line with intervals that never quite stay static; in this way the melodic material becomes a metaphor for the mental state of the anxious saxophonist the composer wishes the performer to portray. The fingering that the composer supplies in the score for the microtone depicted in figure 4.1.4 is a modification of the fingering from Weiss and Netti for

Fig.4.1.4 Fuminori Tanada *Mysterious Morning III* (1996) page 1 line 1



A4 quarter tone sharp, but whereas the Weiss and Netti fingering of *bis* plus the third finger produces a frequency of 406Hz, the composer's suggestion of also adding the fifth finger results in a flatter frequency of 403Hz because it uses a forked fingering. This miniscule difference of 3Hz serves to change the sonic distance between the two notes by making the interval even smaller and therefore highlighting the microtonally diminishing nature of the phrase. This can be demonstrated numerically by working out the sonic distance between each microtonal interval as compared to the standard tempered interval: the intervalic difference between concert E4 to concert G#4 is 86Hz (415Hz-329Hz=244Hz), whereas the intervalic difference between concert E4 and concert G4 quarter tone sharp is 74Hz (403Hz-

329Hz=74Hz). If we were then to repeat the same equation with other fingering choices we would end up with a number of choices as follows:

Table 11: Suggested fingerings for alternative fingerings as taken from Weiss & Netti, Tanada, and Londeix's fingering systems

Pitches	Tanada fingering	Weiss/Netti fingering	Londeix fingering 1	Londeix fingering 2
G4 quarter tone sharp	403Hz	406Hz	407Hz	412Hz
E4	329Hz	329HZ	329HZ	329Hz
Resultant intervalic difference	74Hz	77Hz	78Hz	83Hz

The table shows the differences in interval that can be exploited through the use of different fingering systems and it is clear that the composer has a specific idea of how close he wants this microtonal interval to be in the listener's ear by adding a second forked fingering to Weiss & Netti's suggested fingering closing the gap even more. To demonstrate this I have recorded the interval in figure 4.1.4 using both Tanada's fingering system (track 60) and using Weiss & Netti's fingering system (track 61). The feature of closing the sonic distance between the intervals of the first page continues as Tanada introduces more microtones to the phrase which alters the sonic difference between the two pitches. The written F#4 falls to an F4 quarter tone sharp and so the intervalic difference changes again depending upon which fingering is used:

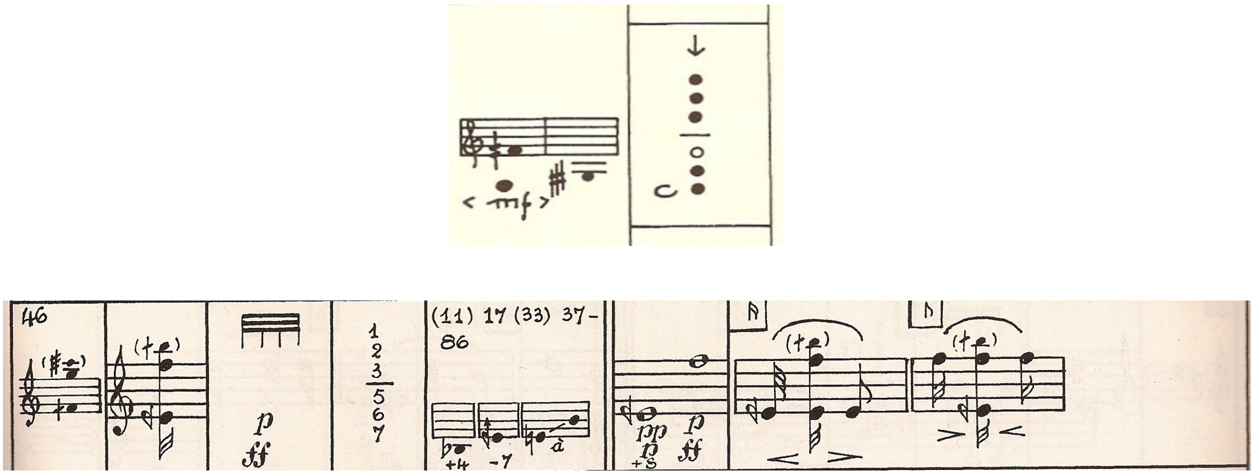
Table 12: Suggested fingerings for alternative fingerings as taken from a mixture of Weiss & Netti, Tanada, and Londeix's fingering systems

Pitches	Tanada fingering	Weiss/Netti fingering	Londeix fingering
G4 quarter tone sharp	403Hz	406Hz	407Hz
D4 three quarter tones sharp	325Hz	324Hz	325Hz
Resultant intervalic difference	78Hz	82Hz	82Hz

If we consider that the difference between concert D#4 and concert G4 is 81Hz (392Hz – 311Hz = 81Hz) then it seems that the Weiss & Netti fingering system is the best suited to maintain the interval of a major third using microtonal versions of these pitches. There are two problems with this fingering system. The first problem is that the fingering for Weiss &

Netti's F4 quarter tone sharp is the same as that of Kientzy multiphonic 46 for soprano as shown in figure 4.1.5, and so some effort needs to be taken to suppress the resultant

Fig.4.1.5 Weiss & Netti's fingering for F4 quartertone sharp and Kientzy fingering for multiphonic number 46



partials that want to sound using the usual method of tongue and throat manipulation. A low tongue position such as 'hod' helps in this instance to suppress the upper partials of the multiphonic and sound only the lowest pitch. This multiphonic also appears later in the phrase and although it is relatively easy to control the manifestation of the multiphonic from the microtonal fingering using the oral cavity, altering the fingering serves as a marked change between one and the other. The second problem for this fingering is that it uses the low C key which the composer wishes us to keep free in order to use to create the *bisbigliando* technique, a fact which renders the Weiss & Netti fingering system unusable as there are no alternatives that will give the same *bisbigliando* effect without the use of the low C key. It is for these reasons that a player can consider mixing two different fingering systems in order to achieve the closest intervalic match for the major third interval through the following combination:

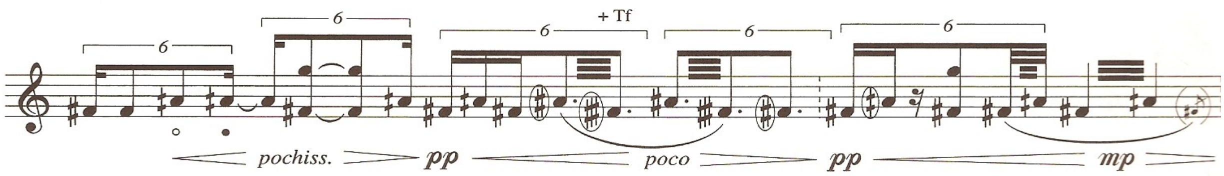
Table 13: Suggested fingerings for the notes G4 quarter tone sharp and D4 three quarter tones sharp from Weiss & Netti's and Londeix's fingering systems

Pitch	Tanada fingering	Weiss/Netti fingering
G4 quarter tone sharp		406Hz
D4 three quarter tones sharp	325Hz	

Resultant intervallic difference	81Hz

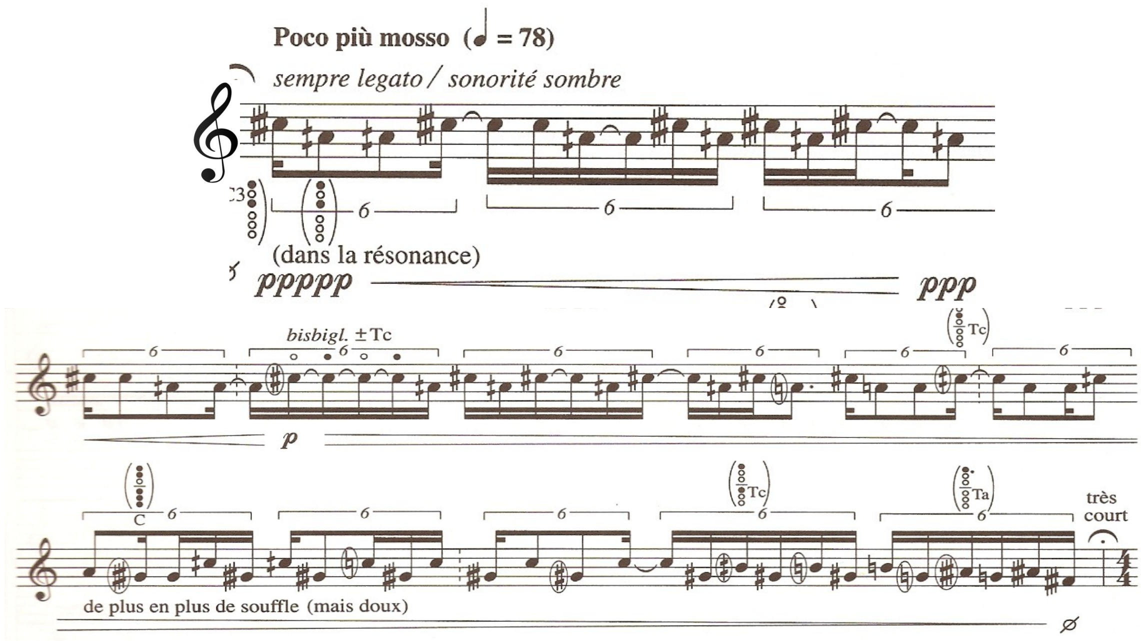
All three resources agree on the fingering for F4 three quarter tones sharp which adds the F# trill key to a regular F# fingering, venting it in such a way as to raise the pitch from 331Hz to 339Hz and once again microtonally diminishing the major third interval between F#4 and A#4 for the microtonal interval in figure 4.1.6. The technique of microtonally augmenting and diminishing the interval of a third (either major or minor) continues on

Fig.4.1.6 Fuminori Tanada *Mysterious Morning III* (1996) page 1 line 5



page seven of the score when the whole passage gradually descends but the top and the bottom notes of the intervals within this overall descent are altered in microtonal increments. The first interval is that of a written C5 three quarter tones sharp with an A4 quarter tone sharp as the lower note as in figure 4.1.7. We have already experimented with the fingerings for A4 quarter tone sharp (concert G4 quarter tone sharp) and so due to the implied minor third interval between the two notes it is once again appropriate to compare fingerings to see which combination is the most accurate.

Fig.4.1.7 Fuminori Tanada *Mysterious Morning III* (1996) page 7 lines 2-4



The intervalic difference between concert G4 and concert B4 (493Hz – 392Hz) is 101Hz, and so this is the target interval for our fingering combinations.

Table 14: Resultant frequencies from Weiss & Netti, Tanada, and Londeix's fingering systems

Pitch (concert)	Tanada fingering	Weiss/Netti fingering	Londeix fingering 1
G4 quarter tone sharp	403Hz	406Hz	407Hz
B4 three quarter tones sharp	510Hz	519Hz	512Hz
Intervallic difference	107Hz	113HZ	105Hz

I have discounted Londeix's second fingering for G4 quarter tone sharp due to its anomalous high frequency (412Hz) as compared to the other alternatives. The above table shows that Londeix's fingerings result in the closest interval to the target of 101Hz; however, we have not yet mixed fingering systems to compare intervallic difference as follows:

Table 15: Resulting intervals for mixed fingering combinations taken from Weiss & Netti, Tanada, and Londeix's suggesations

Respective pitches	Tanada/Weiss&Netti	Tanada/Londeix 1	Weiss&Netti/Londeix 1
Lower pitch/Upper pitch	104Hz	103Hz	112Hz
Upper pitch/Lower pitch	116Hz	106Hz	105Hz

Having mixed the fingering systems the combination of Londeix's fingering for the upper pitch (B4 three quarter tones sharp) and Weiss & Netti's fingering for the lower pitch results in the closest match for the minor third interval implied in the passage. The fingerings for the next intervals in this passage can be calculated in a similar way by working out the target interval and finding the fingerings that achieve the closest sound.

Table 16: Suggested fingerings for alternative fingerings as taken from a mixture of Weiss & Netti, Tanada, and Londeix's fingering systems

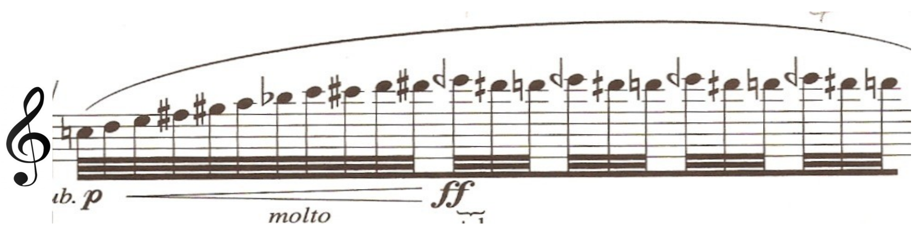
Respective pitches	Tanada/Weiss&Netti	Tanada/Londeix 1	Weiss&Netti/Londeix 1
Lower pitch/Upper pitch	(386Hz-518Hz) = 132Hz	(386Hz-485Hz) =100Hz	(386Hz-485Hz) = 100Hz
Upper pitch/Lower pitch	*(485Hz-386Hz) = 99Hz*	*(485Hz-386Hz) = 99Hz*	(518Hz-386Hz) = 132Hz

Target intervallic difference (466Hz - 370Hz)	96Hz	96Hz	96Hz

The above table shows two possible combinations which are closest to the target interval (in italics) and so it again comes down to practicality to decide which is the appropriate fingering combination. Londeix's fingering for written G three quartertones sharp involves less fingers being depressed than Weiss & Netti's suggestion makes it the desirable fingering for this passage, as fewer fingers makes for an efficient movement from one fingering to the other which helps with speed. The final interval of the passage depicted in figure 4.1.4 is another implied major third between written A4 three quarter tones sharp and F4 three quarter tones sharp. All three sources agree on the fingering combinations for this interval and the resultant intervalic difference is 87Hz with a target interval of 86Hz.

The second use of microtones in Tanada's composition serves to bring consecutive pitches closer together as on page 3 of the score where the interval of a major second appears in microtones between a written E6 a quarter tone flat and D4 a quarter tone sharp (figure 4.1.8). Tanada here presents us with the suggestion to play the regular chromatic version of the pitches but to leave the first finger down creating one finger fork in order to flatten the note.

Fig.4.1.8 Fuminori Tanada *Mysterious Morning III* (1996) page 3 line 4



Again it can be determined which fingerings are appropriate both sonically and practically by measuring the resultant frequencies of each fingering:

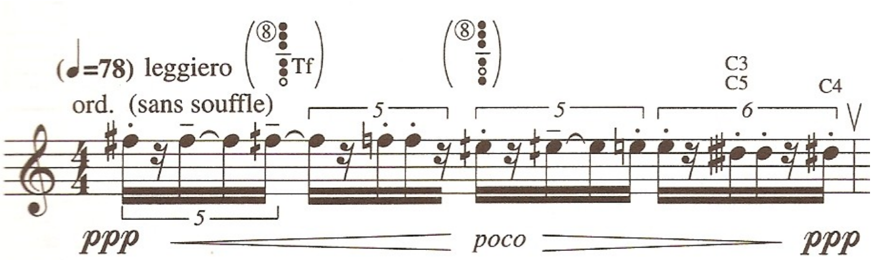
Table 17: Resultant frequencies from Weiss & Netti, Tanada, and Londeix's fingering systems

Target pitch (concert)	Tanada fingering	Weiss/Netti fingering	Londeix fingering
D6 quarter tone flat	1170Hz	1167Hz	1160Hz
C6 quarter tone sharp	1064Hz	*1100Hz*	*1100Hz*

C6	11046Hz	1046Hz	1046Hz

It should be noted that in the above table the values in italics are derived from the same fingerings. Given that the frequency of D6 is 1174Hz it is clear both numerically and sonically that Tanada's fingering in this case produces a note that is too sharp to be identified as a D6 quarter tone flat, it being sonically closer to a D6 one eighth tone flat. This leaves us with a choice between Weiss & Netti's and Londeix's fingerings, which differ in their feasibility; practically Londeix's fingering albeit slightly lower in pitch uses two non-adjacent left hand palm keys (C1 with C4) whilst Weiss & Netti's fingering uses the right hand alongside a single left hand palm key (C4 with C3). This means that the Weiss & Netti's fingering is preferable as it can be executed at the speed required in all instances involving the above pitches because it uses two different hands rather than one hand trying to operate two no-adjacent keys. An extensive passage of consecutive microtones appears on page seven in a descending scale of micro-intervals as can be seen in figure 4.1.9. Using

Fig.4.1.9 Fuminori Tanada *Mysterious Morning III* (1996) page 7 line 5



the same method of determining fingerings based upon their frequencies as compared to the frequency of the closest tempered frequency gives the performer insight into which fingerings may be appropriate.

Table 18: Resultant frequencies from Weiss & Netti, Tanada, and Londeix's fingering systems

Pitches (concert)	Tanada fingering	Weiss/Netti fingering	Londeix fingering 1	Londeix fingering 2	Closest tempered frequency
D5 three quarter tones sharp	652Hz	*651Hz*	*651Hz*		622Hz
D5 quarter tone sharp	*612Hz*	*612Hz*	*612Hz*		587Hz

C5 three quarter tones sharp	581Hz	583Hz	563Hz		554Hz
A4 quarter tone sharp	*459Hz*	453Hz	*459Hz*	466Hz	440Hz
G4 three quarter tones sharp	*429Hz*	*429Hz*	*429Hz*		415Hz
G4 quarter tone sharp	403Hz	406Hz	407Hz	412Hz	392Hz

The chosen fingerings for this passage are in italics. This method ensures that the descending line of the passage can be performed accurately and that the closeness of the microtonal phrase is highlighted as much as possible.

Singing and Playing

The composer writes in the performance directions that 'the voice part should be sung very slightly higher or lower than the instrumental line so as to create beats' (Tanada, 1996). We have already seen the effect altering a sinusoid has on the resulting heterodyne components, and the same mathematics can be applied to the vocal parts in this piece so as to determine whether singing sharp or flat as compared to the accompanying pitch is likely to create the most frequent and complex beating pattern. The first instance of singing and playing simultaneously occurs on page three of the score where the vocal part closely imitates the descending semi-quavers starting on a written F# and descending from that point (figure 4.1.10). In the following table, which uses the heterodyne component equation

Fig.4.1.10 Fuminori Tanada *Mysterious Morning III* (1996) page 3 line 1

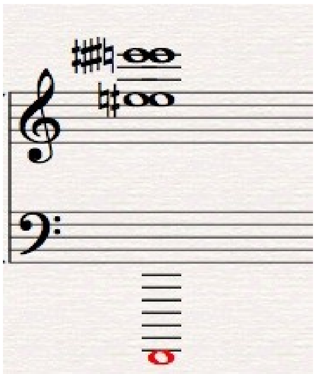
taken from Benade's *Fundamentals of musical acoustics* (1976), P represents the vocal part which is sung an eighth-tone higher than written (approx 670Hz), and Q represents the saxophone playing the notated F#5 (659Hz).

Table 19: Heterodyne component table with values taken from Tanada *Mysterious Morning III* (1996) page 3 line 1

Original Components	Simplest Heterodyne Components
670Hz (P)	(2P) = 1340Hz
	(P+Q) = 1329Hz (P-Q) = 11Hz
659Hz (Q)	(2Q) = 1318Hz

Musically this creates a very close cluster of microtonal notes that can be represented in concert pitch as follows:

Fig.4.1.11 Musical representation of the resultant sounds from the heterodyne relationships between the saxophone's concert E5 and the voice's concert E5 sung sharp



The equation is now repeated but this time the vocal part is sung a quarter tone lower than written; in this new table the saxophone's written F#5 is now represented by P and the vocal part is represented as Q:

Table 20: Heterodyne component table with values taken from Tanada *Mysterious Morning III* (1996) page 3 line 1

Original Components	Simplest Heterodyne Components
659Hz (P)	(2P) = 1318Hz

	(P+Q) = 1300Hz (P-Q) = 18Hz
641Hz (Q)	(2Q) = 1282Hz

With the resultant musical representation appearing as follows:

Fig.4.1.12 Musical representation of the resultant sounds from the heterodyne relationships between the saxophone's concert E5 and the voice's concert E5 sung flat

The musical representations show how each incarnation of this heterodyne action creates beating patterns between the different versions of E6 due to the variance of E5; however, it is a matter of opinion as to which of these is appropriate for this passage. To this end both versions can be heard on the accompanying CD; with the vocal part sung slightly sharp on track 62, and slightly flat on track 63. As the vocal part is descending in this instance vocalising the voice part slightly lower as in the second example will also create heterodyne tension between the (lower) notes that follow in the remainder of the passage, and for this reason I have chosen to vocalise the F#6 slightly lower than pitch.

The second occurrence of this technique is the sharp or flat vocalisation of a Bb3 alongside a tempered Bb3 played by the saxophone as displayed in figure 4.1.13.

Fig.4.1.13 Fuminori Tanada *Mysterious Morning III* (1996) page 8 line 2

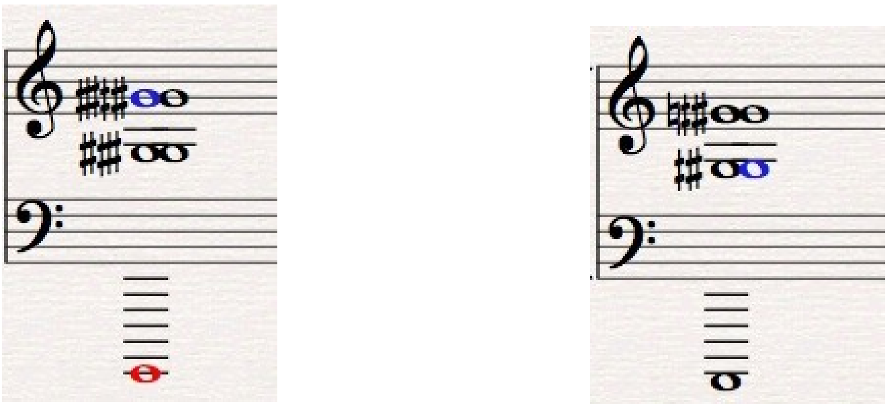
The following table shows the heterodyne behaviour of this new pairing of sinusoids.

Table 21: Resulting frequencies from heterodyne components sounded during Fuminori Tanada *Mysterious Morning III* (1996) page 8 line 2

Equation	Sharp vocalisation	Flat vocalisation
P	213 (voice)	207 (saxophone)
Q	207 (saxophone)	200 (voice)
2P	426	414
2Q	414	400
P+Q	420	407
P-Q	6	7

With the resultant musical representations as follows:

Fig.4.1.14 Musical representation of the resultant sounds from the heterodyne relationships between the saxophone's concert Ab3 and the voice's concert Ab3 sung sharp (left) and flat (right)

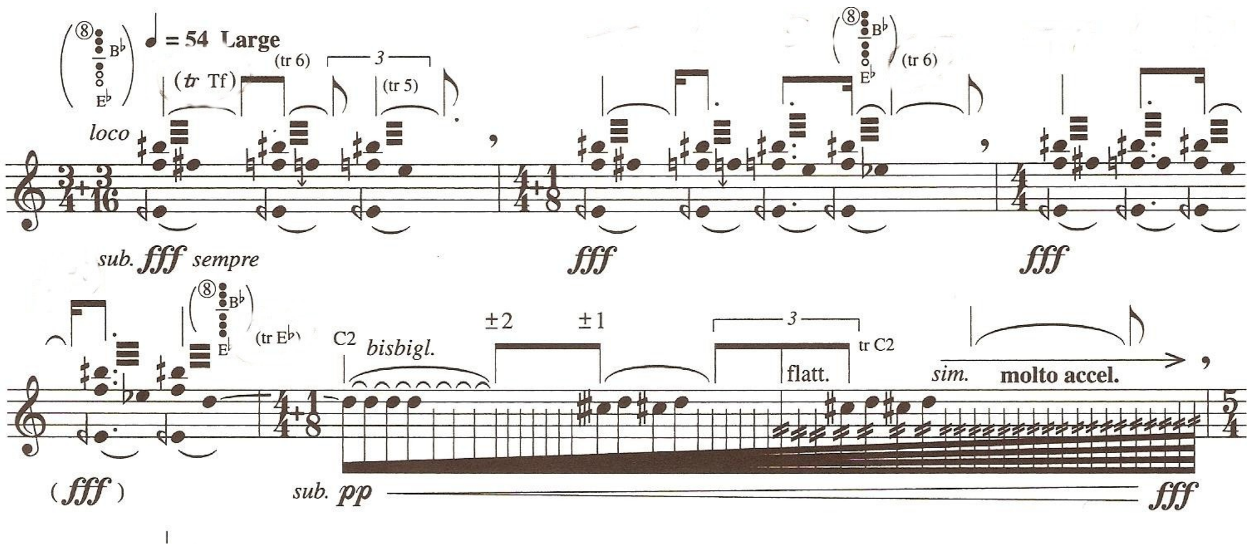


The musical representation of these heterodyne relationships shows that singing the vocal part slightly flatter than the saxophone's pitch creates a closer beating pattern as in the first example (sharp vocalisation) each pitch is a version of G three quarter tones sharp whereas in the second version (flat vocalisation) the pitches shift to include the pitch of G alongside both G quarter tone sharp and G three quarter tones sharp. Again both version can be heard on tracks 64 (sharp vocalisation) and 65 (flat vocalistaion). This cluster of heterodyne activity from singing the vocal part slightly flatter than pitch seems to provide the beating patterns that the composer has asked for in the performance directions.

Multiphonics

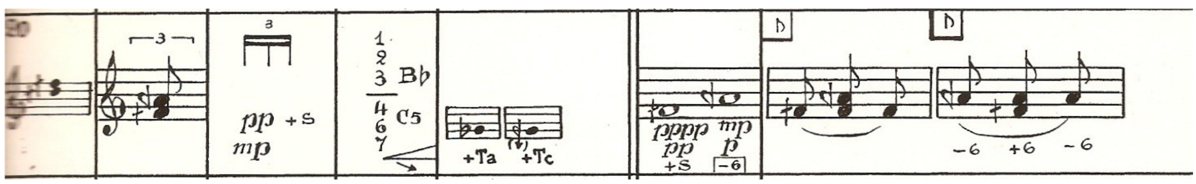
The multiphonics used in the work mostly serve to demonstrate the microtonally descending lines which are an identifying feature of the piece, and it is for this reason that Tanada's choice and subsequent notation of the multiphonics are significant in developing this theme that has already been established to the listener through use of the techniques previously discussed. On line three of the sixth page of the score the descending line is notated in the middle notes of each multiphonic trill giving the impression of a descending passage whilst the surrounding partials of the multiphonics are static (figure 4.1.15). The multiphonic which begins this descending passage is a variation on Kientzy number 20 which

Fig.4.1.15 Fuminori Tanada *Mysterious Morning III* (1996) page 6 lines 3 & 4



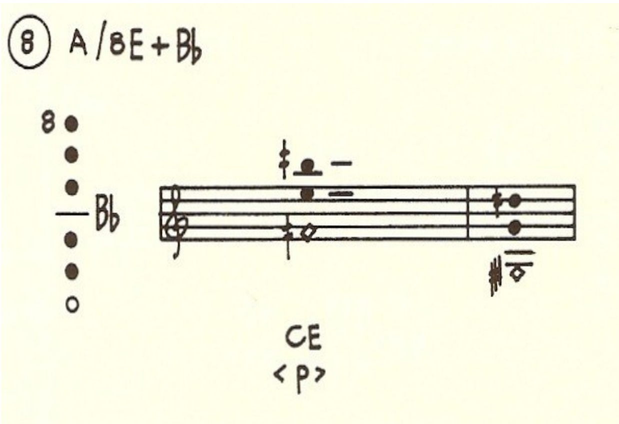
is a type B multiphonic that replaces the low C key we find in Kientzy number 20 (as shown in figure 4.1.16, track 66) with the Eb key, which flattens the middle partial of the multiphonic from 647Hz to 632Hz effectively changing that note from a written F#5 (659Hz) to an F5 natural (622Hz). The addition of the F# trill key to this fingering has the effect of changing the middle partial note from 632Hz (nearly an F5) to 664Hz (nearly an F#5) whilst maintaining the other partials as Tanada's notation suggests. The second multiphonic

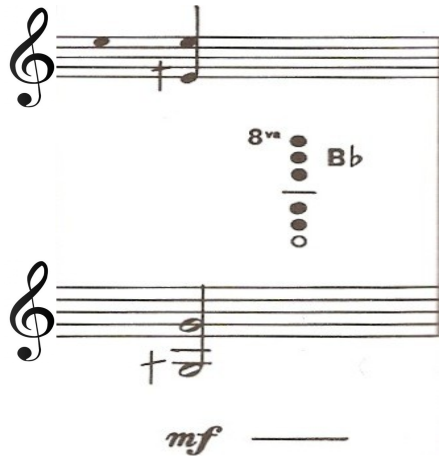
Fig.4.1.16 Kientzy multiphonic number 20 taken from *Les Sons Multiples Aux Saxophones* (2003)



used alongside Kientzy number 20 is to be found not in Kientzy's book but as multiphonic number 8 in Weiss & Netti (2010) and also in Londeix (1989) as shown in figure 4.1.17 (track 67).

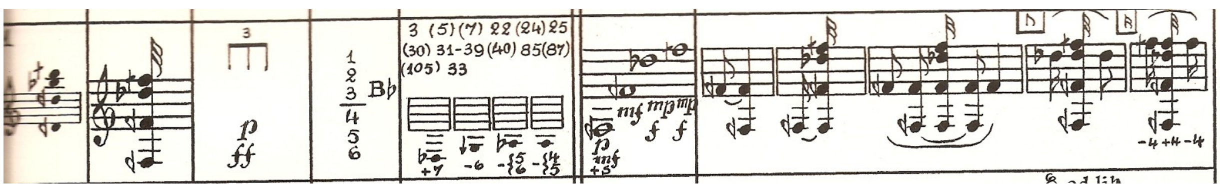
Fig.4.1.17 Weiss & Netti (2010) multiphonic number 8 and the same fingering as shown in Londeix (1989)

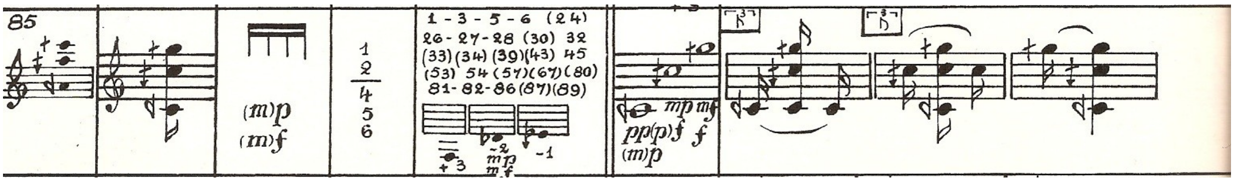




This fingering is also modified through use of the Eb key (enharmonically named the D# key in Londeix's book) which again has the effect of flattening the middle partial to the desired pitch. The final multiphonic to be trilled to is number five in Weiss & Netti, and number three in Londeix, although once again the Low C key is substituted for the Eb key. This substitution, which is present for each multiphonic in this passage, not only flattens the note so that an F5 can be heard but it also means that the saxophonist can leave this finger down throughout the entire passage making for a quick transition between trills. The final trill of the passage is between two new multiphonics; Kientzy number 85 trilling to Kientzy number 1 through use of trilling the same Eb key (both multiphonics can be heard on track 68).

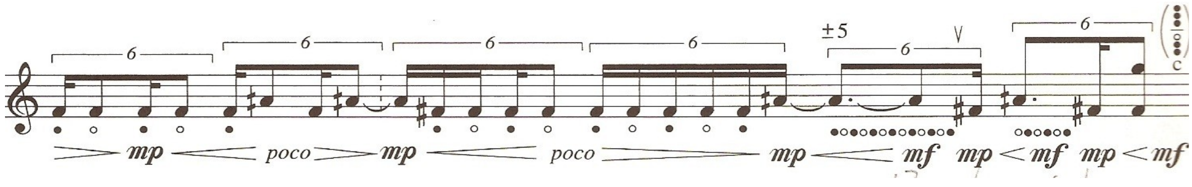
Fig.4.1.18 Kientzy multiphonic numbers 1 and 85 taken from *Les Sons Multiples Aux Saxophones* (2003)





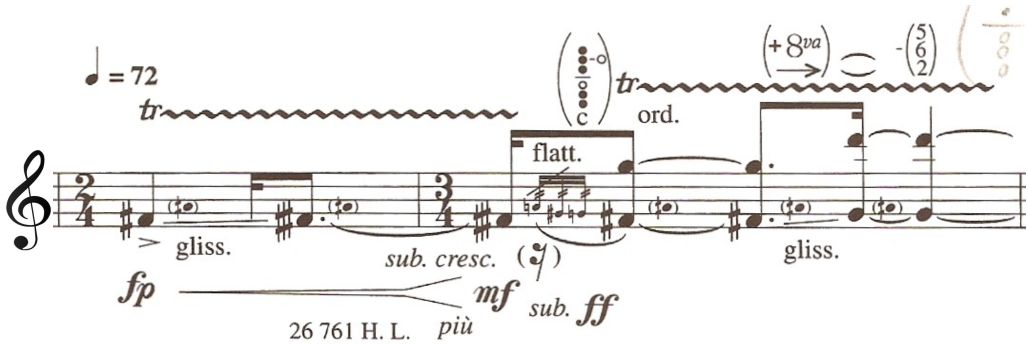
Tanada's fingerings present an ergonomically feasible and musically accurate series of multiphonic trills for this passage; however, as these multiphonics have a strong sounding middle partial the saxophonist must take care to consistently sound the surrounding partials of the multiphonic, as there is a danger that without the correct lip shape and tongue position only the strong partials will sound and the passage will become monophonic. When playing these particular multiphonics the tongue can be held in the same positions throughout the passage as they are each modifications of the same basic multiphonic and therefore the multiphonic type is maintained. Alongside the use of the 'who'd' tongue position which is employed in the production of this technique the jaw is to be dropped slightly downwards decreasing the lip tension on the reed and therefore allowing it to vibrate in a slightly different way. If the jaw is not dropped in this way then the stronger middle partial of the multiphonic will sound on its own and again the passage will become monophonic because the tongue position does not affect the air stream enough in this instance to be effective as the only method of manipulation. If this mixture of tongue placement and jaw displacement is adopted then the multiphonics throughout this entire passage can be performed without further alteration, maintaining both the presence and the tuning of all partials. Apart from its use in Tanada's descending phrases in this piece, Kientzy multiphonic number 46 appears on the first page of the score alongside the microtonal interval of F#4 and A4 quarter tone sharp (figure 4.1.19). The lower note of this

Fig.4.1.19 Fuminori Tanada *Mysterious Morning III* (1996) page 1 line 2



multiphonic is notated as an F#4 and as such acts as a replacement for the preceding version of this note in the phrase to keep the microtonal interval intact, and if we consider that a written F#4 sounds at 329Hz and the lowest pitch of this multiphonic sounds at 327Hz then the tiny difference between the two different versions of F#4 is scarcely enough to be discernible to the listener's ear. What is clearly discernible in practice, however, is the third partial of this multiphonic which is not notated in the score by Tanada but is sonically present in the multiphonic. It is possible to suppress this partial using a subtle amount of the subtone technique but there is a danger of lowering the pitch of the important F#4 which is the lowest partial. As this multiphonic is very flexible the player can choose a number of tongue positions to adopt to get the multiphonic to sound, but it is the 'who'd' tongue position which is most effective in suppressing this top partial which is written in both Kientzy and Weiss & Netti's books as a C5 three quarter tones sharp, but is not present in Londeix's book or indeed in Tanada's score. As with the first group of multiphonics described above it is necessary to adjust the jaw to achieve the desired tuning from this multiphonic and so the jaw is again to be dropped away in this case to suppress the top partial and present the specific interval that is written in the score. The final multiphonic that Tanada calls for occurs on page three of the score immediately after multiphonic number 46 as can be seen in figure 4.1.20. Unlike the other multiphonics used

Fig.4.1.20 Fuminori Tanada *Mysterious Morning III* (1996) page 3 line 5



so far this multiphonic is a type A multiphonic which Weiss and Netti describe as a 'layer of natural overtones over a fundamental' (Weiss & Netti, 2010 p.60). With this type of multiphonic the tongue position is of utmost importance as the fingering is that used for the normal fundamental, in this case the fingering for G5. With this type of multiphonic the saxophonist must be able to pitch the top partial and imagine they are singing this note, thus 'tuning the vocal tract' as discussed in (Chen, Smith, & Wolfe, 2008). There are two tongue positions for this fingering which result in two slightly different multiphonic resonances; the first is the 'who'd' position which results in both G4 and G5 being sounded simultaneously (effectively 'splitting' the note into its fundamental and first partial); and the second tongue position is the 'heed' position which results in the sounding of the notated G4 and D6 but also in a G5 that is not present in the score. Each of these tongue positions has its problems: the first omits the D6 whilst the second includes a G5 and thus introduces a more complex sounding multiphonic overall. Within the context of this piece, and with multiphonic number 46 preceding this multiphonic, the second tongue position which sounds the D6 is the most appropriate as Tanada has specified this interval of a twelfth following the interval of a minor ninth, the first instance in the piece of an interval augmenting instead of diminishing.

Flutter tongue

This effect is used throughout Tanada's piece often in conjunction with other effects so as to add an extra timbral disturbance to a phrase which already has the impression of deterioration. As has been mentioned, the two methods of flutter tongue are the use of the tongue against the soft palate (as in a Spanish rolled 'r') and the undulation of the epiglottis against the back of the throat. The first main occurrence of this is on page three of the score where this technique is used alongside the previously discussed vocalisation during a descending semiquaver passage as previously shown in figure 4.1.9. Due to the *fortissimo* dynamic and the presence of the voice producing heterodyne components, the method of using the tongue against the hard palate for this passage creates a solid and clearly audible disturbance of the air column whereas the undulation of the epiglottis against the soft palate creates a softer effect which is less easily heard amongst the surrounding complex sounds. Similarly at the climax of the section on page six the tongue flutter technique can be used at a louder dynamic in order to be audible over this quick and loud succession of notes. The less harsh flutter tongue effect can be used to advantage in the quieter phrases of the piece as demonstrated by the passage on lines five and six of page seven where the subtone would be destroyed by the presence of a harsh flutter tongue as shown in figure

4.3.21. The throat flutter is appropriate here so that the trilled notes are heard over the percussive flutter tongue effect, which is especially important when there is air sound in the pitches.

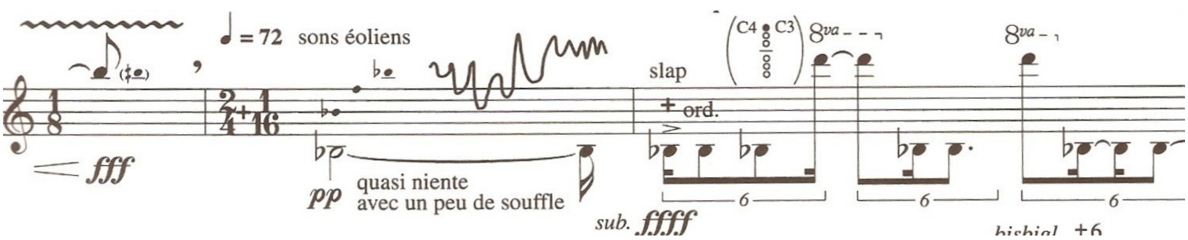
Fig.4.1.21 Fuminori Tanada *Mysterious Morning III* (1996) page 7 line 5

The end of the piece also calls for use of the throat flutter as the phrase *diminuendos* and the sound becomes 'more and more breathy and colourless' until the phrase eventually dies away, and the use of the tongue here would be very audible and overpower the pitches of the trills effectively destroying both the breathiness and the tonality of the final phrase of the composition.

Slap Tongue

Tanada uses slap tongue only once in *Mysterious Morning III* but the placement of this single effect is important as it begins an interlude of extremes of both dynamic and register in amongst two sections that are by contrast at an extremely low dynamic level as shown in figure 4.1.22. The slap effect is written as a normal Bb3 but with the word 'slap' written above it; this suggests that the slap should be pitched to this note to begin the section and it should not be a *secco slap* as described in Weiss & Netti. This is performed by playing a regular Bb3 with a very heavily articulated tongue slap at its beginning sounding both the percussive slap effect and the pitch, which will maintain the overall rhythm of the phrase by fully sounding the first note of the rhythmic group.

Fig.4.1.22 Fuminori Tanada *Mysterious Morning III* (1996) page 6 line 6



Section 2

Nicolaus A. Huber *Aus Schmerz und Trauer* (1982) For Alto Saxophone

In his article on Huber's music printed in *Tempo* John Warnaby writes 'Ultimately, Huber's music avoids undue sophistication. It is not primarily concerned with experimentation, involving the deconstruction of instrumental and vocal sonorities by means of extended techniques, nor is it underpinned by complex philosophical ideas. Its main challenge stems from the vehemence of its expressive language, and the differing perspectives Huber achieves by means of varying degrees of distortion' (Warnaby, 2003 p.37). This clarifies Huber's use of extended techniques not as a means of deconstruction of either tone or material, as we saw in Tanada's *Mysterious Morning III* (1996), but instead as a necessary extension of Huber's own compositional language. Huber was influenced by experimentalism and his compositions take elements from Berg and Nono (Warnaby, 2003 pp.23-28) in his use of rhythm and secret codes written into repeated tones, and his use of extended techniques in instrumental works are used not to destroy the sound but to push performers 'to the point of exhaustion' (Warnaby, 2003 pp.23-28). Warnaby goes on to observe that 'many of Huber's solo instrumental pieces... are usually designed to transcend mere interpretation, to the point where the performer's inner humanity is revealed' (Warnaby, 2003 pp.23-28) which accounts for the variation of sound techniques that use the performers' own physiological makeup to identify one performance from another such as the use of whistling (*'pfeifen'*) and the formation of vowels whilst playing utilising the performers' own vocal tract resonances for fundamental tones.

One of the most identifiable compositional techniques employed by Huber is his theory of conceptual rhythm composition, where taking cues from world music (Huber, 2000 p.575) and the experiments of crowd chants in Bertold Brecht's non-rhyming improvised crowd poetry with irregular rhythm (Huber, 2000 trans. 2008 p.575) which utilises in the composition a 'range of tempo, with fluid and unclear limits at both sides, is appropriate to an active body rhythm. Superheating or sub-cooling respectively, the simple extraction of the rhythmical shaping from the muscular active time frame could be applied as phenomena influencing and regulating each other, from a physically imperceptible pace, “too much” or “too fast” respectively, towards the quasi-timeless expression of the mere inner, spiritual, poetical, atmospheric or similar' (Huber, 2000 trans. 2008 p.574). This 'range of tempo' is used by Huber as a dramatic tool and Huber himself observes that once an accelerando has culminated 'one has reached the border of ecstasy and mania' just as is experienced in African drumming cultures (Huber, 2000 trans. 2008 p.574).

Altissimo

Huber's use of the highest register of the saxophone generally follows the theory outlined by his conceptional rhythm composition method, which uses tempo and in *Aus Schmerz und Trauer (1982)* pitch in order to control the dramatic narrative of the composition. Huber does this by using scales across the whole range of the instrument to highlight narrative denouements usually toward the end of a section, the first of which appearing on page five of the score with an ascending scale into the altissimo register growing out of a rhythmic multiphonic phrase. By using this register in this way the composer covers much of the saxophone's register in a short amount of time resulting in the player's need to familiarise themselves with the tongue positions and fingerings which are most efficient to pitch the notes of the altissimo register with fluidity. Figure 4.2.1 shows the first instance of a chromatic scale into the altissimo register starting on written A6 and finishing at D7 (track 69).

Fig.4.2.1 Nicolaus A. Huber *Aus Schmerz und Trauer* (1982) page 7 line 1

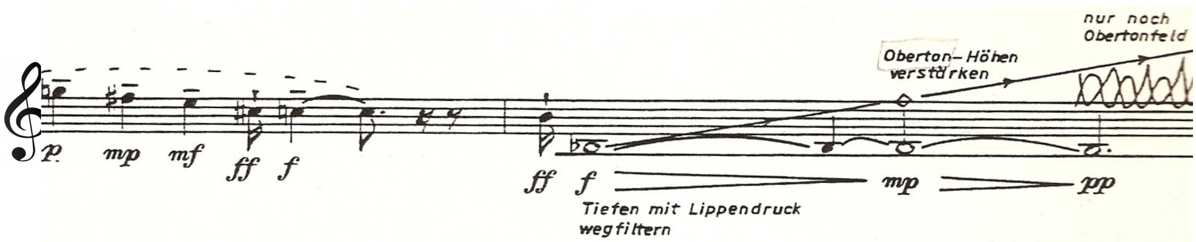
The standard fingering for this register as taken from Rousseau's book suggests a variation on the standard chromatic fingering for C6 to F6 using the 'overblowing a sixth' method Rousseau suggests as discussed previously. This means that the already familiar chromatic fingerings on the palm keys of the instrument can be fingered with a new tongue position to pitch the notes of the altissimo register. When it comes to playing D7, however, the tongue needs to be re-set as the chromatic fingering to F# has been exhausted on the palm keys and so must start again from the fingering for C#6 but this time overblown by a ninth to pitch the correct note. The first tongue position on these palm key fingerings requires the 'head' tongue position in order to pitch the chromatic scale from A#6 to D7, but then the saxophonist must change to the 'heed' or 'hid' tongue position to reach the new partial. This is the same for the passage which begins on page six and continues on page seven, which is also an ascending scale into the altissimo register, however, as the scale does not reach the D7 there is no need to change tongue position during this passage, maintaining the 'head' tongue position throughout. It is worth noting, however, that the tongue positions to be adopted are merely indications of how the player needs to tune their vocal tract (as if singing the note) in order for the note to sound. A combination of air, fingerings and tongue position is not sufficient to switch partials in this register without further manipulation of the larynx which is achieved by imagining singing the note alongside the elements listed. The altissimo register is used differently in other parts of the work where the composer has decided to intersperse notes from this register into a melodic line by way of contrasting both the shape of the line and the timbre of this register. Figure 4.2.2 shows the '*aggressiv*' section at the top of page ten of the score during which Huber identifies and exploits four main registers of the instrument: the first register uses the note C4; the second uses G4; the third moves between E5, F#5 and A5; and the final register is the altissimo pitch G#6. In order to pitch this altissimo note accurately the saxophonist again must pre-empt the tongue position needed in order to secure its production, a tongue position which differs from the other notes of the phrase (track 70).

Fig.4.2.2 Nicolaus A. Huber *Aus Schmerz und Trauer* (1982) page 10 lines 1-2

Harmonics

Huber includes a glissando through the harmonics near the end of the piece, again emphasising the connection between extremes of range and dramatic tension. Figure 4.2.3 shows the notation for the glissando plus the performance directions written alongside it which informs the performer to filter away the lower partial ('Tiefen mit Lippendruck wegfiltern'), to re-enforce the high overtones ('Oberton-Höhen verstärken') and finally to be left with only the overtones ('nur noch obertonfeld').

Fig.4.2.3 Nicolaus A. Huber *Aus Schmerz und Trauer* (1982) page 11 line 2



This effect is once again achieved through use of the different tongue positions from the normal position 'hawed' through 'hood', 'Who'd', 'head', 'hid' and finally to 'heed' in order to pitch the very highest partials (track 7). In this way it is possible to pitch as high as the thirteenth partial (G8) which can then be manipulated with the tongue from 'heed' to 'hid' to realise Huber's ascending and descending effect. It is worth noting that the tongue position of 'heed' needed to reach the unusually high thirteenth partial is very similar to the tongue position need to reach D7 on the soprano saxophone in Tanada's *Mysterious Morning III (1996)* in that the tongue has to withdraw toward the back of the oral cavity creating tension in the neck muscles and tendons. The concert pitch for both of these notes is around a concert C7, giving some credibility to Rob Buckland's claim that tongue position depends on the concert pitch note the player is tuning their vocal tract to regardless of which size of saxophone one is playing on.

Multiphonics

Huber utilises multiphonics in two main ways; firstly he uses triadic multiphonics at the end of sections within the composition which are marked 'so lange und bis so leise wie möglich' (as long and as quiet as possible) with a maximum duration given in seconds. The second group of multiphonics Huber uses are dyads which interject within a melodic phrase, and therefore relate closely to the pitches immediately surrounding them. It is the relationships between the multiphonics in each group that allow us to decide which pitch relationships are the most significant

Figure 4.2.4 shows each triad multiphonic in the order that they appear in the piece, these multiphonics can be heard in sequence on track 71. The upper notes of the first two multiphonics in figure 4.2.3 ascend from Bb5 to Fb6, and then the third and fourth multiphonic's upper notes descend from G6 to C6 giving a rising diminished fifth and then a falling perfect fifth. The lower notes of each pair of multiphonics follow a similar

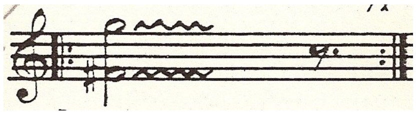
Fig.4.2.4 Triad multiphonics in order of appearance in *Aus Schmerz und Trauer* (1982)

ascending/descending pattern; the first pair rising by a diminished fifth and the second pair descending a diminished fourth. The middle notes of each pair of multiphonics follow in parallel with the first pair of notes ascending by a major third and the second pair descending by a minor third. This ascent followed by descent represents the piece as a whole and is concurrent with Huber's conceptual rhythm composition technique in that the pitch rises to 'superheat' the dramatic tension which then 'sub-cools' when the pitch descends. In order to maintain the harmonic relationships between these multiphonics the saxophonist must pitch the top note of each multiphonic to ensure it sounding at the correct pitch. If the multiphonics are sounded from the lowest fundamental to the highest there is a danger that the highest note will not be sounded properly being that it is the last to be produced in these type B multiphonics. This method of production ensures the pitch relations within each multiphonic pair as the lower partials will sound as a result of pitching the highest ones.

Fig.4.2.5 Nicolaus A. Huber *Aus Schmerz und Trauer* page 6 lines 2 and 3

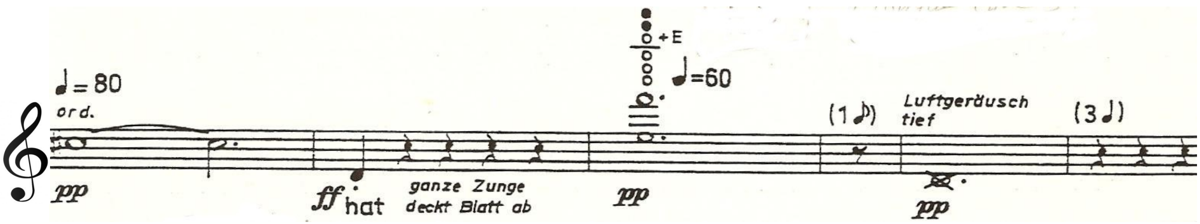
The second group of dyad multiphonics, which intersect a melodic line, have their own individual relationships with the music around them. The first of these type C multiphonics is based around a C#5 and a C#6, which connects to the surrounding pitches in two ways: the preceding D#5 falls to the C#5 of the multiphonic whilst at the same time the C#6 is sounded which then falls to a B5 (see figure 4.2.5). The dual purpose nature of this multiphonic means that both partials need to be sounded as strongly as the other and so the player needs to pitch the highest partial whilst relaxing the lower jaw slightly allowing the lower fundamental to sound; I have also found that as this multiphonic is based upon a modified C4 fingering the notes produced are significantly flatter than C# sounding closer to a C natural. The addition of the octave key adds a vent to this fingering that raises the pitch sufficiently for it to be identified as a C# by the ear. The second dyad to employ this type of multiphonic voice-leading is depicted in figure 4.2.6, where the G5 leads to a G#5 after an increase of both speed and dynamic. This multiphonic is achieved again with the fingering or Kientzy multiphonic number 67 but ensuring that the C#5 that is present in the sound is

Fig.4.2.6 Nicolaus A. Huber *Aus Schmerz und Trauer* page 11 line 1



suppressed by pitching the vocal tract to the G5 and using a slight amount of relaxed jaw pressure to ensure the top partial does not sound. The final dyad Huber uses is a type D multiphonic which is an aggregate of two or more partials over a fundamental (Weiss and Netti, 2010) and comes seemingly in isolation from the music that surrounds it as shown in figure 4.2.7. Here Huber attaches the multiphonic to the preceding phrase connecting the

Fig.4.2.7 Nicolaus A. Huber *Aus Schmerz und Trauer* page 9 line 5



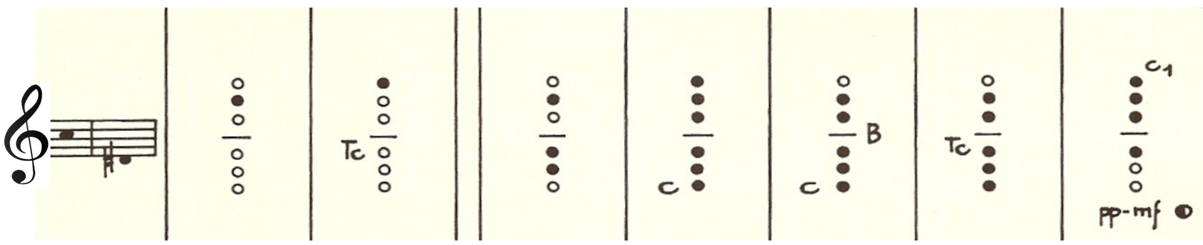
two by their dynamic, and so whereas the E5 of the multiphonic is a minor third higher than the C#5 in the previous *pianissimo* phrase, the D4 is also a minor third lower than the F#4 from the previous *fortissimo* phrase. As the interval of a minor third is significant in this passage the E5 or lower partial of the multiphonic is the note that is to be emphasised; however, this is counter-intuitive with this type of multiphonic as the higher partial needs to be pitched in order to achieve the multiphonic at all; the lower partials are sounded by drawing the lip back and downwards effectively 'splitting' the note and sounding the partials.

As stated these are the main ways Huber uses multiphonics in the work, however, a type B multiphonic is also given a third role as it is used to emphasise a repeated rhythm in the work that the listener has heard previously. It is therefore the rhythm and articulation of this multiphonic that is to be given importance in performance as it needs to match the previous material. As this multiphonic is a stable one, the tongue can be used as normal in order to articulate the rhythm in a comparable way to the monophonic version which occurs earlier in the work, as long as the 'who'd' tongue position is maintained throughout.

Timbral Fingerings

A large amount of the second section of the piece includes Huber's specific rhythms that characterise his conceptual rhythm composition technique, and these rhythms are performed using timbral fingerings which are numbered from 1 to 6. Huber tells us at the beginning of the score that these numbers represent 'alternate fingerings for a tone. The higher the number, the more the tone colour should vary from the "normal fingering", i.e. it should become increasingly darker.' Huber is using the mechanics of the instrument to highlight the respective tone qualities between dark and light, much like Scelsi's direction for 'chiaro' (dark) and 'cupo' (clear) pitches that appear in *Maknongan* (1986) which was to come four years later. Figure 4.2.8 shows the fingering chart from Weiss & Netti (2010) showing the alternate fingerings for the note C5 on the alto saxophone, these fingerings are organised from the standard pitch to the left, to just below the pitch (second fingering) and

Fig.4.2.8 alternate fingering chart for C5 taken from Weiss & Netti (2010)



on to the fingering that is the brightest in pitch to the extreme right. This is problematic in that the composer has asked for a succession of alternative fingering which should 'become increasingly darker' varying downward from the normal fingering. Weiss & Netti's suggested fingerings takes us in the opposite dirtection ascending upwards from the normal fingering. Table 22 shows the frequencies in Hz that result from Weiss & Netti's suggestions.

Table 22: Resultant alternate fingerings frequencies from Weiss & Netti (2010)

Fingering	1 (normal)	2 (trill)	3	4	5	6	7
Frequency	311Hz	309Hz	312Hz	313Hz	315Hz	318Hz	319Hz

Only the second fingering in the table above is lower in pitch than the normal fingering and so more fingering combination are to be explored in order to flatten or 'darken' the sound. Figure 4.2.8 shows Londeix's fingering suggestions for *bisbigliato* and their resultant frequency which, with the exclusion of the ± trill indication, can be used as alternate fingerings for the note C5.

Table 23: Resultant alternate fingerings frequencies from Londeix (1989)

Fingering	(normal)	1	2	3	4	5
Frequency	311Hz	310Hz	306Hz	307Hz	319Hz	313Hz

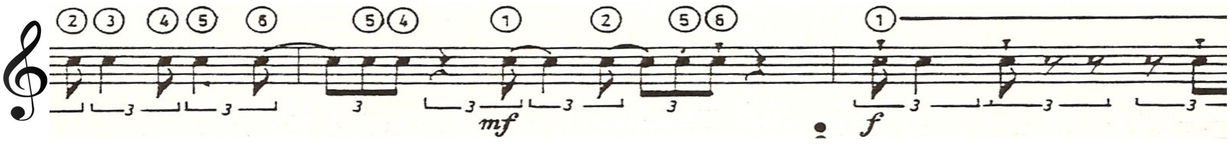
This fingering system still only presents three fingerings that are lower in pitch than the normal frequency of 311Hz, but by mixing the two fingering systems a succession of alternate fingerings can be achieved which begin slightly higher than normal pitch (313Hz) and then become progressively 'darker'. Table 24 represents a potential suggestion of the necessary fingering choices to realise the passage from Huber's composition by showing which fingering system will provide a successively lower pitch for the appropriate number stipulated by Huber in the score.

Table 24: Suggested fingerings for alternative fingerings as taken from a mixture of Weiss & Netti's and Londeix's fingering systems

Huber number (from the score)	1	2	3	4	5	6
Fingering	Weiss & Netti 4	Weiss & Netti 3	Londeix 1	Weiss & Netti 2	Londeix 3	Londeix 2
Pitch	313Hz	312Hz	310Hz	309Hz	307Hz	306Hz

By using this system the passage of rhythmic pitch alterations can be performed as Huber intended which is to have a sound which gets progressively darker in sound from number 1 to number 8 as shown in figure 4.2.9 (track 72).

Fig.4.2.9 Nicolaus A. Huber *Aus Schmerz und Trauer* (1982) page 5 line 3

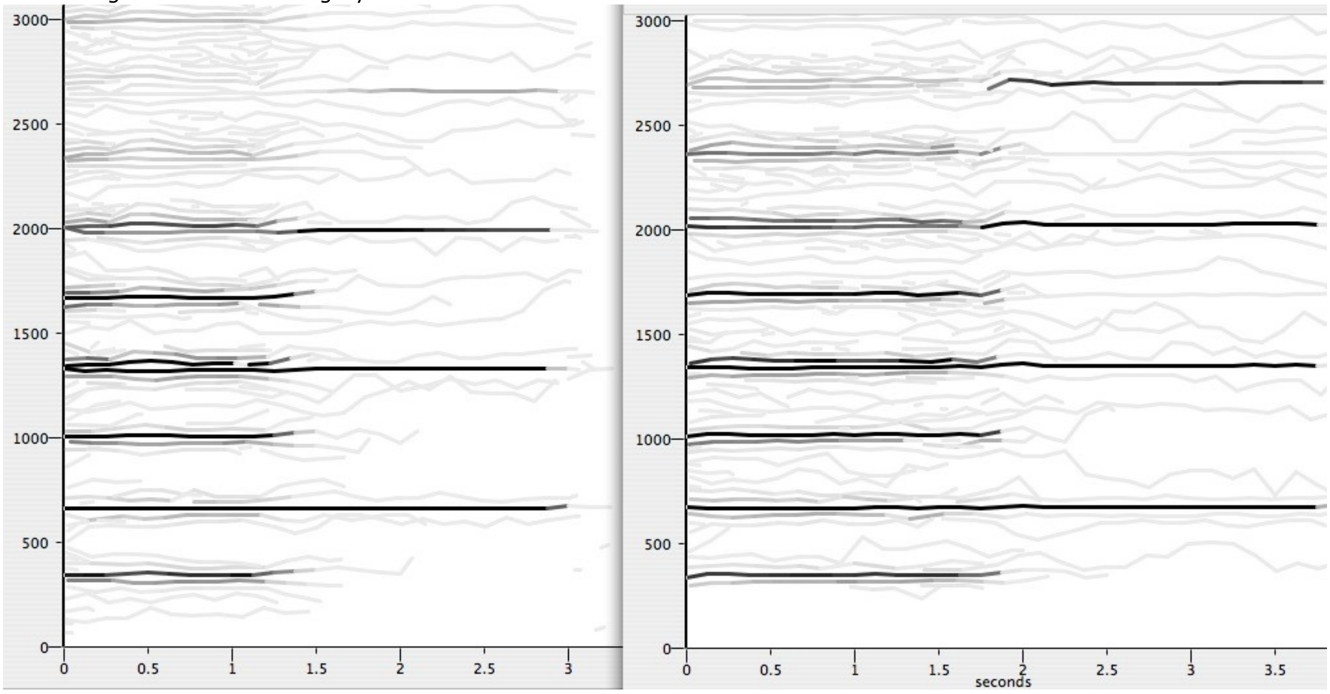


Embouchure Techniques

It has already been said that Huber wished to reach a point where the 'performer’s inner humanity is revealed' (Warnaby, 2003) through un-conventional performance techniques and the exploitation of a performer's own physical makeup to ensure each performance is slightly different depending on the player. In this way the composer hopes to 'transcend mere interpretation' by presenting certain techniques which will be sounded differently by each player. The first such technique related to embouchure involves the movement of the lip on the reed to create, as the composer puts it, a 'lip glissando from the rear of the reed and back. However, a pitch glissando should be avoided' (Huber, 1982). In doing this movement the saxophonist is placing their lip in the middle of the reed constricting its vibration and therefore allowing only a certain portion of the reed to vibrate. This creates a disturbance in the timbre of the pitch which woodwind players refer to as 'splitting' the note, as various partials tend to sound when the reed is constricted in this way. By rolling the lip forward so that it retains contact with the reed the player is able to keep contact with the reed throughout the gesture resulting in a rhythmically controllable sound which affects the timbre of the pitch but not the pitch itself. As this is not an established technique, each saxophonist will perform this differently depending on the mouthpiece and reed combination the player chooses to use. To demonstrate this, I have used the SPEAR spectrum analyser to measure the difference in timbre between two different mouthpieces whilst performing this 'split' tone as depicted in figure 4.2.10. The resultant sounds can be heard on tracks 73 (Vandoren) and 74 (Freddie Gregory) of the accompanying CD.

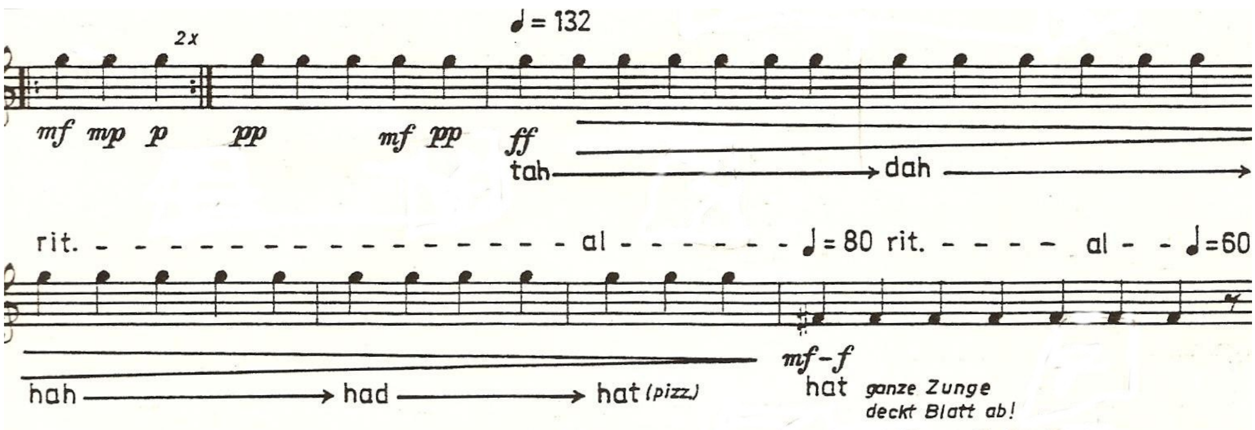
Figure 4.2.10 shows the two different mouthpieces producing very similar results; however, the Freddie Gregory mouthpiece produces more upper partials in the sound and therefore a brighter sound than the Vandoren AL3, this is subtly evident in listening to the sound of the technique as demonstrated on the accompanying CD.

Fig.4.2.10 SPEAR analysis of two different mouthpieces performing the C# timbre gliss, the left is a Vandoren AL3 and the right is a Freddie Gregory F6.



The second type of embouchure technique Huber employs is a type of articulation which varies the timbre of the notes according to the performers' own way of pronouncing certain vowel shapes. Figure 4.2.11 shows a passage from page nine of *Aus Schmerz und Trauer* (1982) which stipulates that the saxophonist should produce pitches using specific articulations, mostly beginning with the breath and ending with a specific tongue attack.

Fig.4.2.11 Nicolaus A. Huber *Aus Schmerz und Trauer* page 9 lines 3 and 4



These articulations work best if they are produced literally with the tongue articulating against the hard palate which means moving the tongue from its normal position beneath the mouthpiece to a position above the mouthpiece normally reserved for the tongue flutter technique. This tongue displacement makes the distinction between the vowels that end in 'd' where the tongue is above the mouthpiece, and the vowels that end in 't' where the tongue is in the normal playing position.

The final timbral variation that Huber asks for that affects the embouchure is for three different type of 'luftgeräusch' or air sound: Low ('tief') middle ('mittel') and high ('hoch') as shown in figure 4.2.12. In order to sound three distinct timbres for this air sound the embouchure must be changed so that the pressure around the reed is either high or low depending on whether the player has the mouthpiece in their mouth or not. The low air sound is simply achieved by relaxing the normal embouchure so that air is still directed

Fig.4.2.12 Nicolaus A. Huber *Aus Schmerz und Trauer* page 9 lines 6 and 7

down the instrument, and the air seal is tight around the mouthpiece, but there is not sufficient pressure on the reed to elicit a vibration from the reed. The middle air timbre involves opening the seal around the mouthpiece by dropping the jaw but maintaining the lower lip contact with the reed, in this way the air can travel over the top of the mouthpiece as well as over the reed and therefore into the bore of the saxophone. The light air sound is a variation of the middle embouchure technique whereby the jaw is lowered in a similar way; however, for this sound the saxophonist is to direct the air directly into the reed at a high velocity using the 'hid' tongue position (as if one is pronouncing a hard 'sss' sound or hiss). If these three embouchure techniques are used in conjunction with each specific fingering, then it is possible to sound different air timbres on the same note as the composer requires in this passage (track 75).

Circular Breathing

As Warnaby explained in his article, one of Huber's interests is the idea of pushing performers to 'the point of exhaustion' (Warnaby, 2003). On page six of the score the saxophonist is asked to create a continuous a passage of semiquavers, which are repeated, out of which the next phrase grows with crotchets appearing to interrupt the flow of the music. This transformation from semiquavers to crotchets is systematic and is to be played over a great deal of time, Huber stipulates that the first crotchet should not appear until 20 to 30 seconds of unbroken semiquavers. Huber writes in the score the direction 'das modell standig wiederholend in die rhythmus-form der nachsten stufe ubergehen' ('the model constantly repeats in the rhythmic form whilst carrying onto the next step'). This puts the performer in a position where they must use circular breathing throughout this semiquaver passage otherwise the music will be abruptly interrupted. During a passage like this the slight dip in pitch which is often heard whilst circular breathing due to the change from storing air in the cheeks to breathing in through the nose is hidden as it cannot be heard amidst the flow of notes. Using circular breathing will not push the performer to an exhaustion point but will maintain the melodic line, as Huber wishes, and so to keep the rhythmical intensity which will be continued in the following bars by an ascending scale into the altissimo register, and so circular breathing should be used here.

Section 3

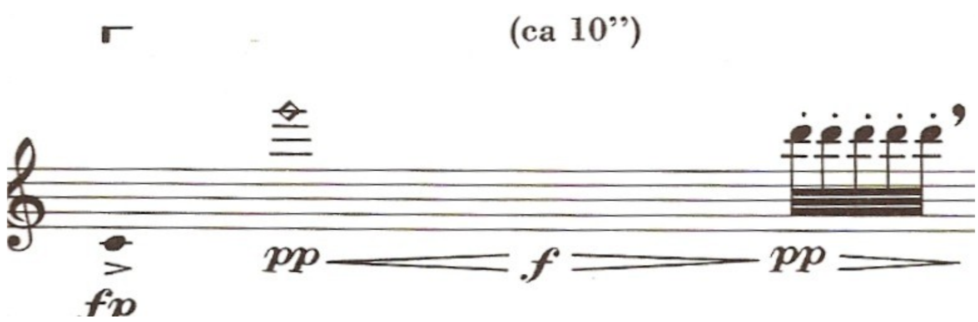
Betsy Jolas *Épisode Quatrième* (1983) For Tenor Saxophone

The performance note for Jolas's piece reads as follows: 'This piece, completed in September 1983, is the fourth in a series with the same title intended for a solo instrument. It may be observed that the piece calls for a member of the large saxophone family that is curiously little used outside the field of jazz. Thus the work clearly falls in line with the research taken at the time in *"Points d'or"* for one saxophonist playing 4 saxophones. In short, the present piece is designed to offer a step-by-step exploration of the entire register of this fine instrument with an almost systematic outward and return journey' (Jolas, 1983). The latter part of this note is of most interest when considering the extended techniques used throughout the work, as the 'step-by-step exploration' allows us to approach each technique as a new sound and ability of the instrument, aided by Jolas' composition which she herself describes as 'systematic'.

Pitch Techniques – Harmonics

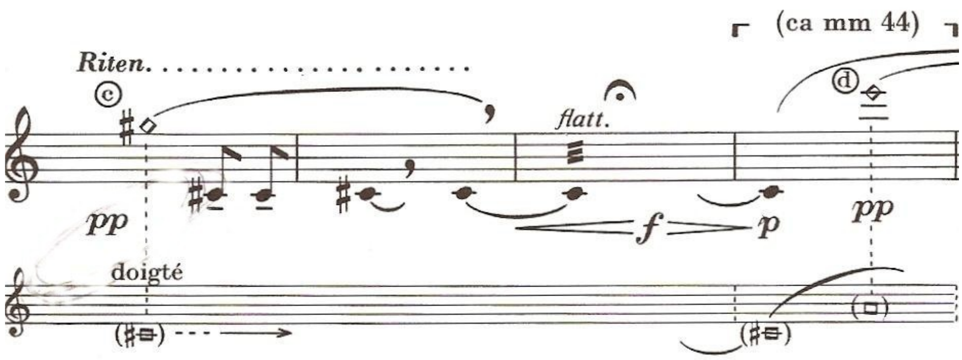
It has been mentioned that extracting harmonics from the larger saxophones is much easier than on smaller models as the wavelengths of the harmonics have quite a low frequency, allowing more opportunities for nuance in the tongue and throat positioning. This is a fact that Jolas seems to have exploited in her composition as manipulation of the harmonics are featured throughout the work. The first occurrence of this technique is shown in figure 4.3.1 (track 76), where Jolas notates the harmonic G6 to be played as the fifth partial of the fundamental of C4, which is the preceding pitch in the phrase. Jolas has therefore stipulated that the performer should play the high G as the fifth partial of C, and so a specific tongue

Fig.4.3.1 Betsy Jolas *Épisode Quatrième* (1983) page 3 line 6



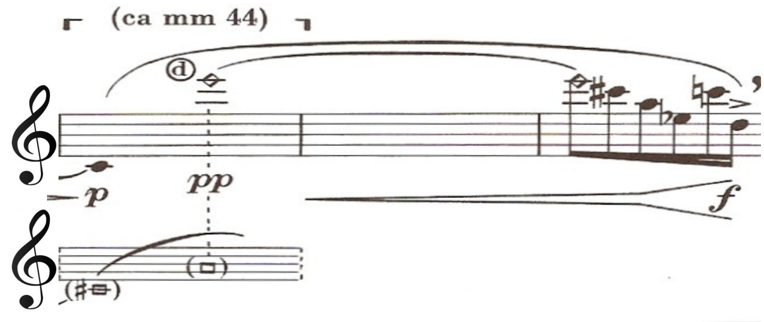
and throat position will need to be learned to achieve this effect smoothly. For this partial the 'Hod' tongue position (as explained in chapter 2) works alongside the widening of the larynx: this combination is often thought of as bringing the tongue 'backwards' in the mouth and raising it towards the soft palate. There is a very high level of specificity in this tongue position: if the tongue slips even a millimetre too high towards the soft palate, the performer will over-blow to the fifth partial and sound a G6, whereas if the tongue is not high enough, the third partial C6 will be heard. It is to this level of specificity that Rob Buckland refers in the previous chapter by stating that 'the recall is just so demanding to remember... This is what composers forget.' Whereas the level of recall needed for these techniques is indeed demanding, I believe it is this 'systematic journey' of discovery throughout the instrument's compass that the composer wishes to harness. Jolas enhances the sense of exploration by adding a second effect whilst pitching the harmonics the next time they are heard, as shown in figure 4.3.2 (track 77). Here, a harmonic of G#5 is notated, which is the second partial of the C#4 fundamental. However, Jolas denotes that the fundamental should sound at intervals whilst the harmonic is being sustained. In this case, the tongue position to pitch the harmonic is more toward the 'heed' tongue position, with a thicker amount of tongue toward the back of the oral cavity. Once the note has been pitched, this tongue position is then alternated with the normal playing position of 'hawed'

Fig.4.3.2 Betsy Jolas *Épisode Quatrième* (1983) page 5 line 2



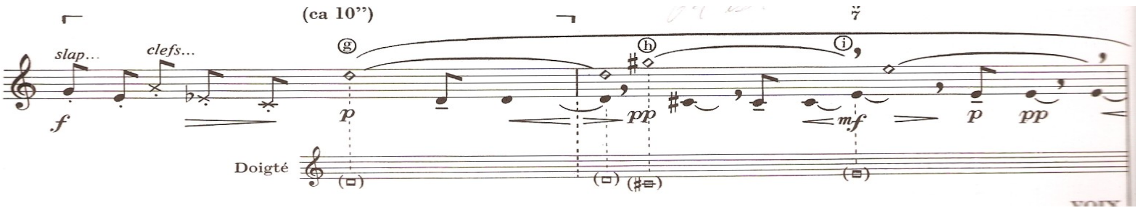
and thus the effect is created. It is tempting whilst doing this to lower the jaw in order to expose more reed to the air stream and thus help the fundamental to sound; however, doing this is a risk. The player would need to re-pitch the harmonic using the tongue at the same time as exposing more lip to the reed in order to sound the partial, which would greatly increase the amount of recall, as well as any margin for error. It is much more accurate to move the tongue only in this instance, which helps to sustain this tricky partial throughout the gesture albeit creating more work for the tongue. This gesture is immediately followed by another harmonic of E6, which this time is the third partial of the note A4 produced through the 'heed' tongue and throat position (as shown in figure 4.3.3, track 78). The final use of this technique is shown in figure 4.3.4 (track 79), where we find similar sustained harmonics with the fundamentals sounding at intervals.The difficulty in sustaining the sound here is that the composer calls for different partials to be sounded

Fig.4.3.3 Betsy Jolas *Épisode Quatrième* (1983) page 5 line 2



per gesture, and therefore, the tongue positions alter with each one. The first and third gestures at this point are simply the first partial of the fundamentals D4 and E4 respectively, for which the 'who'd' tongue position is used to over-blow at the octave.

Fig.4.3.4 Betsy Jolas *Épisode Quatrième* (1983) page 6 line 6



However, the gesture that comes between them is again the second partial of C#4, and as we have already seen, this partial uses the 'heed' tongue position making for quick movement on the part of the saxophonist between one and the other. Again it is important for the player not to drop the jaw whilst making the transfer from one partial to the other as this will sound the stronger sounds (the first partial and the fundamental) over the weaker second partial. In each case, the player is required to recall these specific tongue and throat positions with speed and accuracy in order for the partial to sound smoothly whilst the fundamental is being sounded (giving the illusion of two simultaneous sounds), and for the harmonics to fit seamlessly into the surrounding musical phrase.

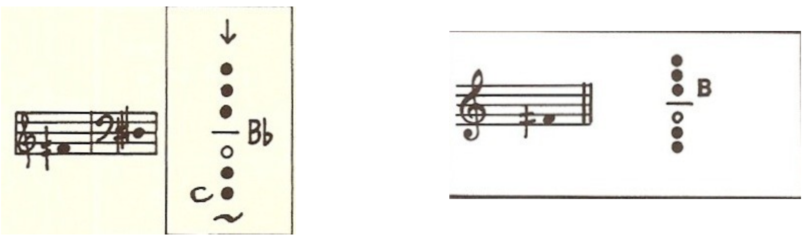
Microtones

Jolas's use of microtones in every instance of their occurrence juxtaposes the note with their tempered counterpart, thus highlighting the microtonal nature of the phrase. With one exception (which we shall discuss later) each microtone centres around the note F4 or F5, which Jolas uses as the point from which she begins her 'outward and return journey' of exploration through the instrument's capabilities. The first appearance of microtones occurs on the fourth line of the first page where an earlier phrase of Gb4 (164Hz) descending to F4 (155Hz) is diminished by a quarter tone becoming F4 quarter toner tone sharp descending to an E4 quarter tone sharp. After consulting Londiex (1989) and Weiss & Netti (2010), both texts agree that the fingering for the E quarter tone sharp is 123-46, with the Weiss &

Fig.4.3.5 Fingering suggestions for the note E4 quartertone sharp as taken from Weiss & Netti (2010) and Londeix (1989)

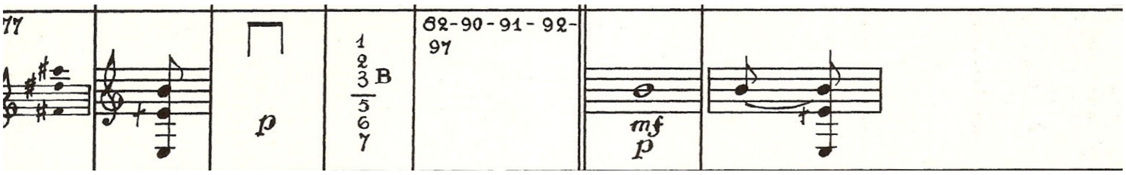
Netti text adding the C# key (see figure 4.3.5), sharpening the sound by a tiny and largely inaudible fraction with my equipment. However, the two texts disagree on the fingering for F quarter tone sharp; Londiex suggests 123-56 plus the low B key, and Weiss & Netti suggest 123-56 plus the low C and Bb keys as shown in figure 4.3.6. In both cases the fingering on the body of the instrument is the same; however, the additional keys differ, resulting in the Londiex sounding at 163Hz, and the Weiss & Netti sounding at 162Hz. When playing Londiex's suggestion it is quickly apparent that other notes want to sound with this fingering, and after consulting Kientzy (2003) it is evident that this fingering is very close to Kientzy multiphonic number 77, which has the addition of the low C key as well as this same core fingering (see figure 4.3.7). This multiphonic does indeed include an F4 quarter tone sharp but also the F5 three quarter tones sharp and the C#6, and when playing this

Fig.4.3.6 Fingering suggestions for the note F4 quartertone sharp as taken from Weiss & Netti (2010) and Londeix (1989)



fingering, the saxophonist needs to add a certain amount of subtone to the sound in order to suppress the partials of the multiphonic which are trying to sound. The Weiss & Netti fingering alleviates this problem through the addition of the low Bb key which stops the multiphonic from sounding. The addition of the low C key flattens the sound from 165Hz to 164Hz and thereby differentiates it from an F4 three quarter tones flat making this fingering both accurate and stable. The second appearance of a quarter tone around the note of F4 is on the second page where the pitch G4 quarter tone flat descends to an F#4. In this case both texts agree that the fingering for this note is 123-5 with the addition of the F# trill key; this sharpens the F# from 329Hz to 340Hz, falling short of a G by 9Hz, and appears to be the only option available for this note.

Fig.4.3.7 Kientzy multiphonic number 77 as taken from *Les Sons Multiples Aux Saxophones* (2003)



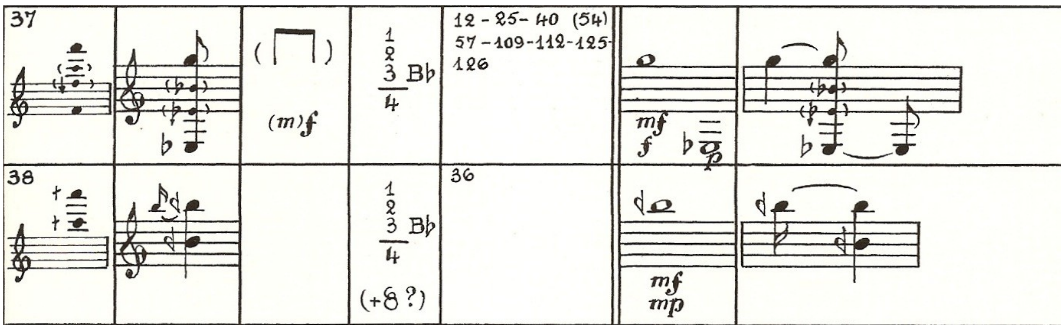
The third and final quarter tone in the piece is an A5 three quartertones sharp, descending to A5. Again both texts agree on the fingering of *bis* plus the side Bb trill key, however I have found that the addition of the third finger to this fingering raises the pitch slightly from 424Hz to 426Hz, with the next eighth tone of B5 a quartertone flat sounding at 430Hz and the B natural (concert A) sounding at 440Hz. With the addition of this third finger I can choose to make the sonic gap between the A5 three quartertone sharp and the A5 even wider increasing the interval and thus highlighting the microtonal character of the phrase.

Multiphonics

It has already been mentioned that the main tone this piece expands from and retracts to is F4. To emphasise this sense of a return 'journey', Jolas's first multiphonic is based around this same tone. This multiphonic is derived from a mixture of Kientzy multiphonic numbers 37 and 38, which have the same fingerings but number 38 has the octave key added as denoted in the score's fingerings (see figure 4.3.8) . Interestingly Kientzy number

37,which does not have the octave key, corresponds closer to the score's notation than number 38 does, which has the correct fingering but different notation according to Kientzy. It is due to this that I have chosen fingering number 38 as is denoted in the score. It is also interesting to note that different tongue positions, and how much lip is exposed to the reed,

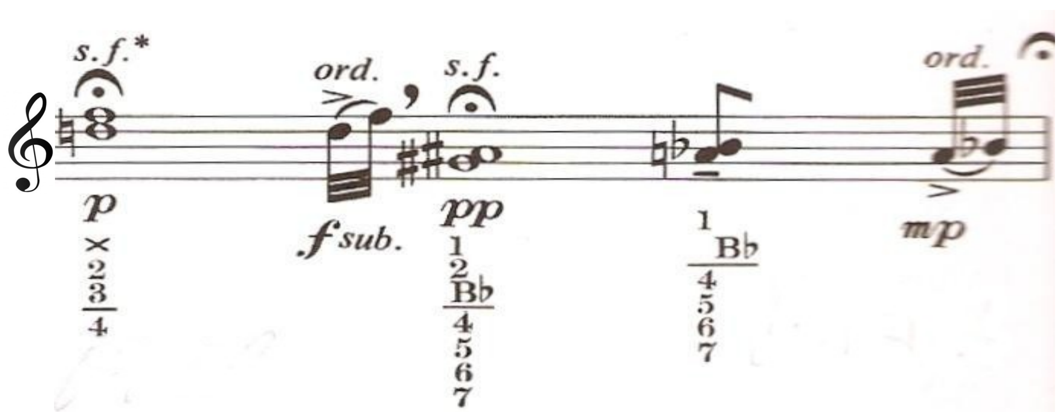
Fig.4.3.8 Kientzy multiphonic numbers 37 and 38 as taken from *Les Sons Multiples Aux Saxophones* (2003)



effect how the multiphonic sounds. Kientzy number 38 sounds easily when blown using the normal 'hawd' tongue position, however, I have found that if the tongue is raised toward the soft palate, the upper partials of this multiphonic are more audible. This accentuation of the upper partials is in keeping with the composer's wish for an 'exploration of the entire register' from the nucleus of the note F4, therefore this multiphonic could be seen as a representation of the entire piece in miniature. The 'heed' tongue position accentuates the upper partials of this multiphonic whilst still sustaining the F4achieving the desired effect at this point in the work.

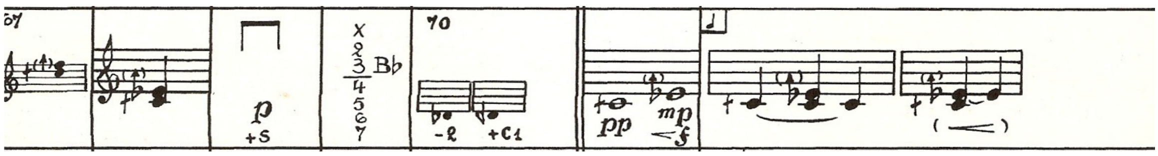
The next group of multiphonics Jolas uses are type E narrow dyads marked '*sons fantômes*' or 'ghost' sounds as shown in figure 4.3.9 (track 80), the name of which acts as a clue to their production and resultant sound.

Fig.4.3.9 Betsy Jolas *Épisode Quatrième* (1983) page 6 line 5



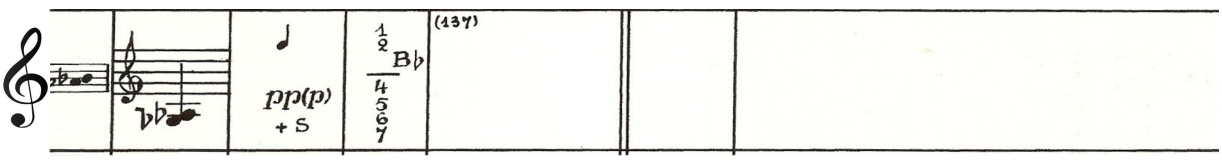
Not all of the fingerings for these dyads are represented in the usual reference materials but they do appear to be variations of existing multiphonics. The first multiphonic in the phrase is a variation on Kientzy number 67 (figure 4.3.10), which is notated a quartertone sharper

Fig.4.3.10 Kientzy multiphonic numbers 67 as taken from *Les Sons Multiples Aux Saxophones* (2003)



than the notes written in the score; this is due to the addition of keys 5, 6 and 7, which serve to sharpen the dyad. Kientzy notes in his description of this multiphonic that it produces an airy sound, which is true in that the dyad is only produceable at a very quiet dynamic level and it is the tipping point between tuned breath and reed vibration that creates the multiphonic. This tipping point of breath engagement with the reed is notoriously difficult to find and so a performer will find the use of the 'who'd' tongue position helpful in aiming for the top note of the dyad. This should allow for just enough breath to sound the lower of the two notes, which is entirely in keeping with Jolas's *'sons fantômes'* performance direction. The second multiphonic in this phrase corresponds exactly to Kientzy number 5 (figure 4.3.11) which also includes the symbol denoting the presence

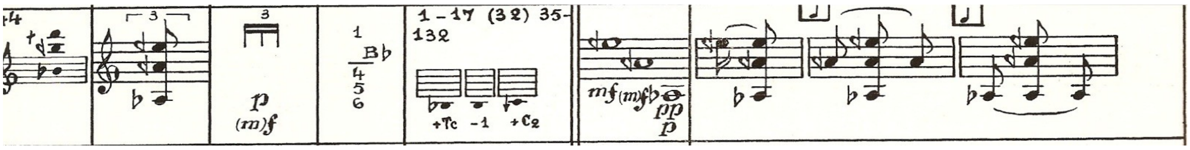
F*ig.4.3.11 Kientzy multiphonic number 5 as taken from* Les Sons Multiples Aux Saxophones *(2003)*



of an airy sound. The 'hood' tongue position is useful in securing this dyad as well as the dropping of the jaw, which allows the reed to vibrate further along its length thus sounding the necessary beating patterns for this minor second interval. It is important to play this multiphonic at an extremely low dynamic level for two main reasons: firstly, because it fits aesthetically with those sounds around it, contrasting with the *forte* interjection between the multiphonics; and secondly, because the movement to the third multiphonic (a variation of

Kientzy number 44 shown in figure 4.3.12) from the second relies on the same delicacy of air to reed engagement. In this instance the addition of

Fig.4.3.12 Kientzy multiphonic number 44 as taken from *Les Sons Multiples Aux Saxophones* (2003)

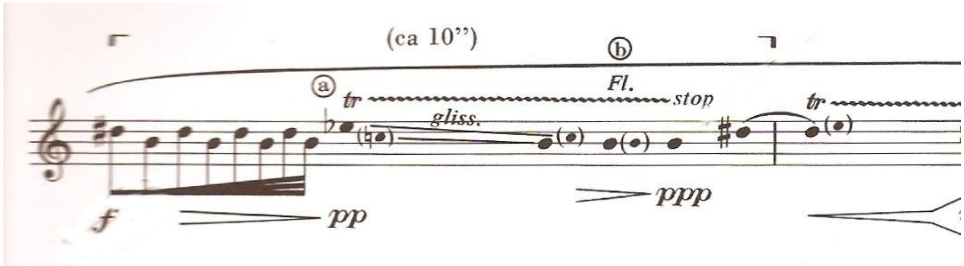


the low C key suppresses the upper partials of the multiphonic and again, the dyad is played in the 'hood' position with more reed exposed in the mouth to create a very subtle but audible lower note. By referring to these multiphonics as 'ghost' sounds the composer has, in my opinion, shown some understanding of their production and the nuance of oral cavity manipulation involved. The player is therefore able to use the presence of air sound and the transient nature of these particular dyads to their advantage, creating sonic 'phantoms' at extremely low dynamic levels.

Timbral Techniques – Trills

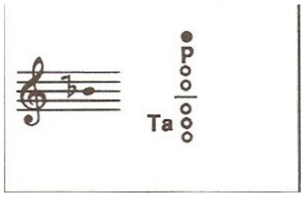
Another feature of this piece is the use of what the composer describes as '*Flattement* – timbral trill (rapid change of enharmonic fingerings)'. It is worth noting that the player has much less choice over 'enharmonic fingerings' than they would if they played other instruments such as the clarinet, oboe or bassoon, all of which have some alternate fingering systems for certain notes. This is due to the saxophone's simple design and can make finding some alternate fingerings difficult, especially on notes lower down the instrument's bore where fingering alternatives are limited. Therefore the saxophonist relies on harmonics and vented notes to create the timbre change. The first trill of this type that occurs in *Épisode Quatrième* (1983) is displayed in figure 4.3.13 and is on the note B4. As this note is located toward the top of the saxophone's cone there are options of activating a lower key to change the timbre of the note; however, due to the fact that the harmonic B4 is created by fingering a low B3 and over-blowing to the first partial, this sudden engagement of the whole air column inside the tube at a high velocity makes this option

Fig.4.3.13 Betsy Jolas *Épisode Quatrième* (1983) page 3 line 2



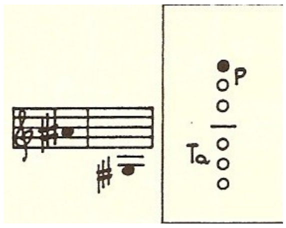
unstable and cumbersome, ruling it out as an option. Having eliminated the harmonic, the only option left is to add lower keys to change the timbre. In doing so, the danger of sounding a micro-tonal trill instead of a timbral trill is created, so a great deal of care must be taken in the choice of fingering to avoid this. The fingering for B4 quarter tone flat suggested in Londiex is shown in figure 4.3.14 and results in a note that sounds at 213Hz, falling short of the B4 (concert A3 = 220Hz) by 7 Hz. As we are attempting to find alternate fingerings for the same note in order to achieve a timbre change, rather than a pitch change, both of these fingerings offer too wide a gap between the micro-tone and the note being trilled. Likewise, the fingering for B3 quarter tone sharp sounds at 230Hz, a full 10Hz

Fig.4.3.14 Fingering suggestions for the note B4 quartertone flat as taken from Londeix (1989)



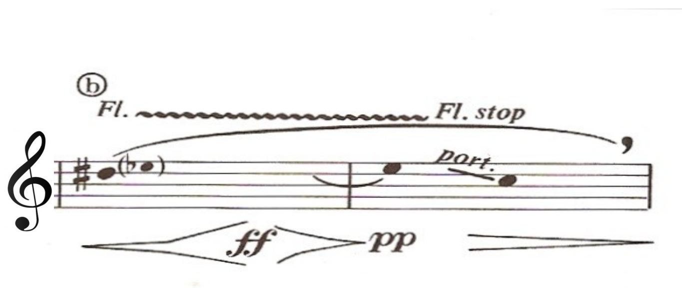
sharper than B3 and only 3Hz flatter than C4. There are two easily executable alternative fingerings which alter the timbre, but not the pitch, of this note; the Bb trill key could be added to B3, or the third finger could be depressed. As these keys are in a similar place on the body of the instrument, they both comply with Benade's principle of tone hole lattice behaviour, acting as a one-finger fork as described in chapter 2. In practice, the first fingering (addition of Bb trill) produces a frequency of 221Hz, and the second fingering (addition of third finger) produces a frequency of 218Hz. Similarly in consultation with Weiss & Netti (2010), there are two fingerings suggested surrounding B4: B4 an eighth-tone flat, which sounds at 215Hz, and B4 an eighth tone sharp, which sounds at 223Hz (see figure 4.3.15).

Fig.4.3.15 Fingering suggestions for the note B4 quartertone flat as taken from Weiss & Netti (2010)



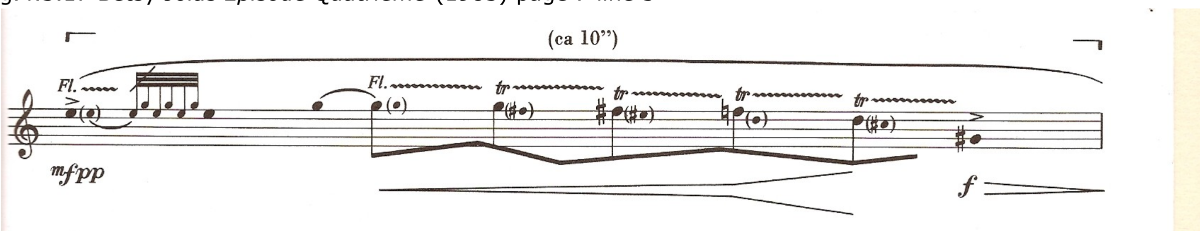
These eighth and quarter tones do not come as close in pitch to Benade's fork fingering technique. This is why I have chosen the method which produces an alternative to the standard micro-tonal fingerings giving us pitches that are much closer in frequency to the target frequency of 220Hz. Between the two fork-fingered alternatives, the former (*bis* plus the Bb trill key) is the more desirable. This is because the Bb trill key is situated adjacent to the Eb trill key, which is used in the previous gesture for the embouchure trill technique (to be described in the next section) as shown in figure 4.3.16, and so the transition into this passage will be made easier and quicker. Similarly, the next use of this technique, as shown in figure 4.3.16, includes the timbral trill on the note Eb5. It is common to use the C3 key to execute Eb trills and *tremolos;* however, we arrive at the same problem as before differentiating between a timbral or microtonal trill.

Fig.4.3.16 Betsy Jolas *Épisode Quatrième* (1983) page 5 line 3



The written Eb5 has a frequency of 277Hz, yet, to maintain this fingering and add the C3 trill key will give us a frequency of 286Hz, which again is a very audible interval. None of the fingerings in either Londiex or Weiss & Netti are possible in this case as too much movement is needed to remove fingers from the Eb and replace them with palm key fingerings; this will make them impracticable for the speed needed for the trill. Therefore, a fork-fingering will close the low B key (or C key, but the relevant finger needed is in use) and will result in the desired sound. Instead, a vent could be used by opening the C1 palm key, which is roughly adjacent to the highest closed tone hole of the fingered Eb. The forked-fingering produces a frequency of 275Hz and the vented fingering produces a frequency of 272Hz. Again, with both fingerings producing frequencies close to the target fingering of 277Hz, it's for practical reasons that the C1 venting solution seems suitable in this case as the use of this palm key will produce a quick and fluent trill (track 81). The timbre trills toward the end of the piece (figure 4.3.17) work in similar ways to the timbre trill on C6, which are attainable through a forked fingering (2-345) producing a frequency of 464Hz (target frequency 466Hz), and the trill on A4 also

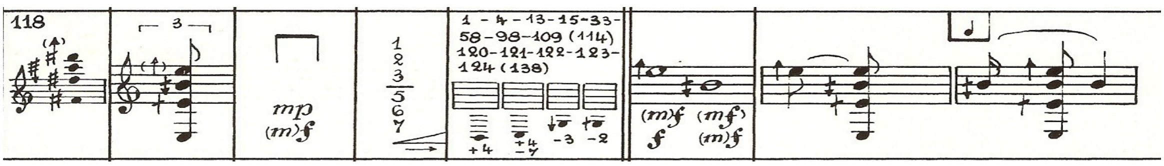
Fig.4.3.17 Betsy Jolas *Épisode Quatrième* (1983) page 7 line 5



using a two-fingered fork (12-45) resulting in a frequency of 194Hz with a target of 195Hz. The trill on E5 works slightly differently through the use of a venting and adding the "C3" key, which produces the frequency 292Hz with a target of 293Hz. All of these timbre trills have been achieved by either a forked-fingering, remaining consistent with Benade's tone hole lattice theory, or have used a vent key to produce a second version of the note, which is very close in frequency to the original.

The last timbre trill of the piece is a trill on G5 (also shown in figure 4.3.17) and here this method hits a problem: due to the saxophone's design, any right hand finger that is depressed will close the F# pad, causing the note to sound, and any left hand little finger key that is depressed will open the G# key, causing the note to sound. This only leaves the right hand little finger as an option to create a fork-fingering. However, because the pads that the left hand little finger operates are so far away from the G pad (4 tone holes on the lattice) the resultant change in pitch or timbre is so small that they'd be unsuitable for this effect. Here we must turn to a third method of production and create a G harmonic to trill with the G5; this is achieved with the addition of fingers 4, 6 and the low C key. Some tongue manipulation is needed here as this is the fingering for the multiphonic numbered 118 in Kientzy's book (figure 4.3.18) which is one of the most commonly used and stable multiphonics attainable on the saxophone and includes the note G5. Therefore, it is possible to sound this partial on its own by adopting the 'heed' tongue position, which does not affect the original note, and thus the two notes can be trilled with this new fingering (track 82).

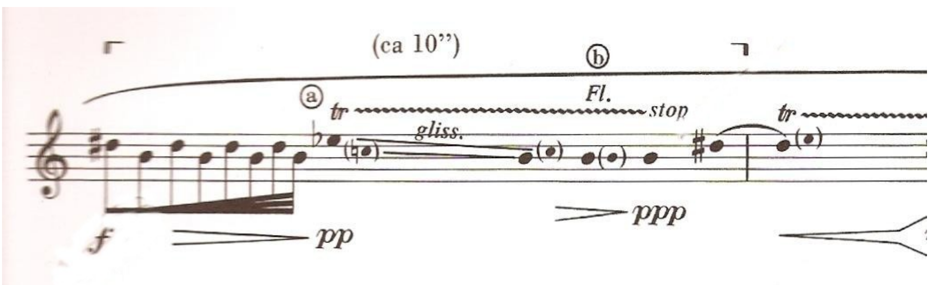
Fig.4.3.18 Kientzy multiphonic number 118 as taken from *Les Sons Multiples Aux Saxophones* (2003)



Embouchure Effects

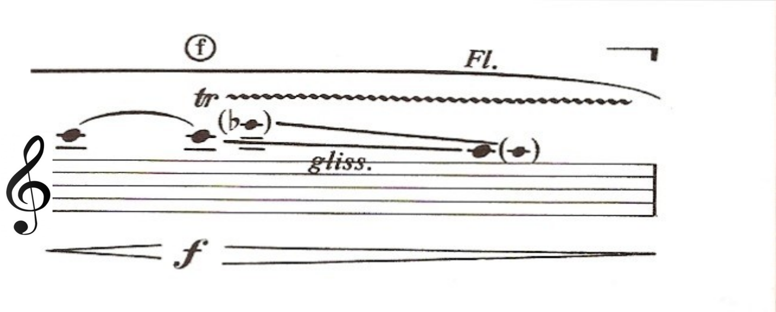
To complement the timbre trills Jolas includes a gesture beginning as a *tremolo* of a minor third which then undergoes a descending *glissando* to become a timbre trill on a lower note as shown in figure 4.3.19. Jolas describes the technique in her performance directions as follows: 'Use the side-fingerings for the e - eb trill and progressively drop the jaw until a timbral trill on B (flattement)' (track 83).

Fig.4.3.19 Betsy Jolas *Épisode Quatrième* (1983) page 3 line 2



The first time this technique is encountered the glissando finishes at the note B4 and the *tremolo* is between the pitches C5 and Eb5, whereas the second time we encounter the technique, the *tremolo* is one octave higher and the glissando now descends to A5 through dropping the jaw as shown in figure 4.3.20 (track 84). When executing this technique the player needs to consider the amount of jaw movement needed to flatten the C6 down to a

Fig.4.3.20 Betsy Jolas *Épisode Quatrième* (1983) page 5 line 6

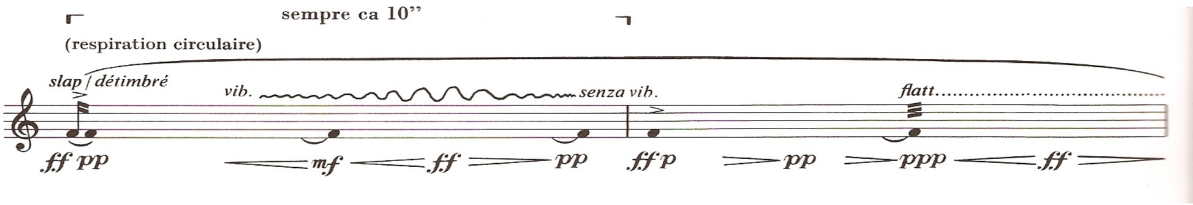


B5 using the lip. Jolas is correct in that the jaw lowers with the lips in place to achieve the effect but in order to create a timbre trill on B4 without splitting the note whilst sustaining the same fingering, the jaw must lower so much that the mouthpiece is pulled away from the top teeth, which are normally anchored on the roof of the mouthpiece. This action creates a very loose seal around the mouthpiece that flattens the pitch sufficiently; however, it also creates more air sound as the player is creating a version of subtone for this effect. When the technique is repeated later in the piece it appears one octave higher and descends to an A5. In this register, as partials are sounding instead of fundamentals, a different approach can be taken to this technique by using high to low tongue positions to glissando the pitch downwards. To do this the player begins in the 'heed' tongue position and gradually moves through 'head', 'hood' and finally to the 'hod' position as well as dropping the jaw as the composer suggests. This final position should pitch a minor third lower (C6 to A5 as shown in figure 4.3.20) and since we are pitching a partial now using specific tongue positions the trill key becomes a vent giving us our timbre trill.

Duration Techniques – Slap Tongue With Key Percussion

Jolas's use of slap tongue throughout the piece is often at high amplitudes in order to accentuate a dynamic change from *forte* to *piano.* This is certainly the case at the beginning and end of the work where slap tongue is used as shown in figure 4.3.21. Elsewhere in the

Fig.4.3.21 Betsy Jolas *Épisode Quatrième* (1983) page 1 line 1



piece, slap tongue is often used alongside key percussion to give the effect of a timbral crescendo including an increase in dynamic. Figure 4.3.22 shows this technique where the articulation moves from key percussion to slap tongue and finally to normal articulation in line with the dynamic *crescendo* (track 85). In figure 4.3.23 the reverse of this occurs: slap tongue followed by key percussion following the contours of a *diminuendo* (track 86). To create this timbral dynamic shift, the performer can easily change from one technique to the other. However, to maintain the pitching effect of the key percussion, the saxophonist needs to close the saxophone's tube by pushing the reed closed with the tongue as described previously. This will add pressure at one end of the instrument and create a standing wave inside the instrument, thus exploiting the full resonance of the instruments' bore. This technique is also advantageous as the performer's tongue is against the reed ready to perform the slap tongue technique.

Fig.4.3.22 Betsy Jolas *Épisode Quatrième* (1983) page 5 line 4

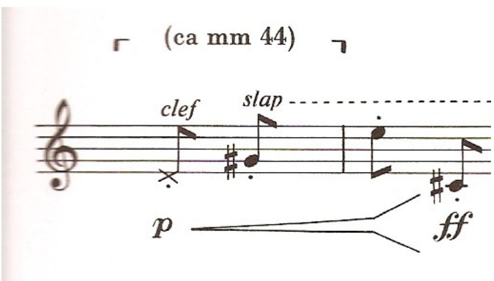
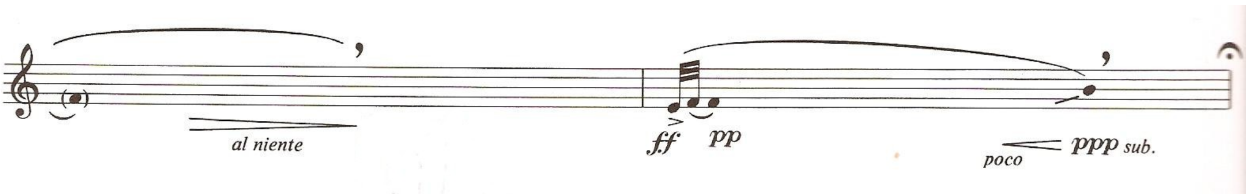


Fig.4.3.23 Betsy Jolas *Épisode Quatrième* (1983) page 3 line 2

Circular Breathing

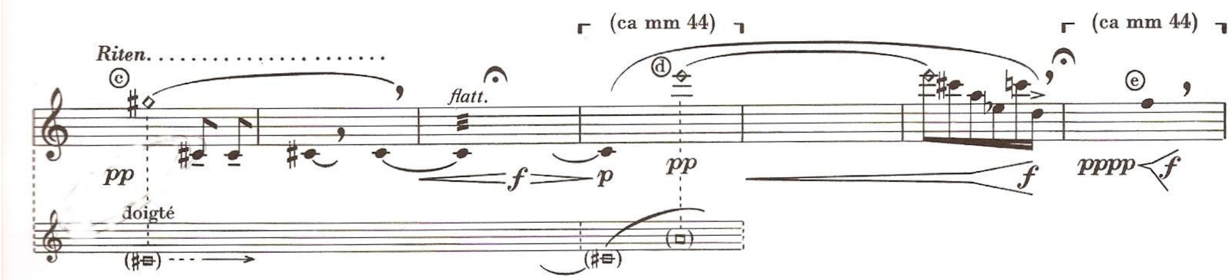
Jolas stipulates at the beginning of the score that the performer should employ the use of '*respiration circulaire*' for the whole of the opening section. The performer therefore, needs to be careful as to where the breath should be taken through the nose so as not to disturb the sustained F4 that is a feature of this work. There are clues in the score as to possible places to switch breath support from the lungs to the cheeks, and these tend to be when the dynamic level drops to extreme levels such as *ppp* or *al niente,* as shown in figure 4.3.24. To accentuate this extreme dynamic the use of subtle subtone is advantageous not only to push the dynamic to the edge of sound production by restricting the reed's vibration with the lip, but also to suppress any partials that may wish to sound whilst altering the embouchure through circular breathing (a side-effect of releasing the pressure of the embouchure whilst circular breathing that in practice can be difficult to control). It is also advantageous to choose breathing places around trills and quick moving notes to disguise any slight dips in pitch.

Fig.4.3.24 Betsy Jolas *Épisode Quatrième* (1983) page 1 line 3



It is common for the first partial to be stronger during this transition of breath from lungs to the cheeks, and so, when playing harmonics in the piece, the saxophonist can elect to transfer breath at points where this partial is sounded. The composer has provided some clues through the use of comma breath marks, indicating where the fundamental should stop sounding (see figure 4.3.25), and so the performer can use these as reliable places for the transfer.

Fig.4.3.25 Betsy Jolas *Épisode Quatrième* (1983) page 5 line 2



Section 4

Ichirô Nodaïra *Arabesque III* (1983) For Alto Saxophone and Piano

Jerome Rosen writes that 'Nodaïra's music may be far-out, but it is by no means gimmicky. He has found a musical language appropriate to the untraditional use he makes of his instruments. The piece moves along in clear and consistent fashion to create an elegant, convincing form' (Rosen, 1984). It is the creation of a musical language that represents a non-gimmicky approach to the use of extended technique which is the focus of Nodaïra's *Arabesque* series.

The composer states in the liner notes of Claude Delangle's recording entitled *The Japanese Saxophone* (1998) that:

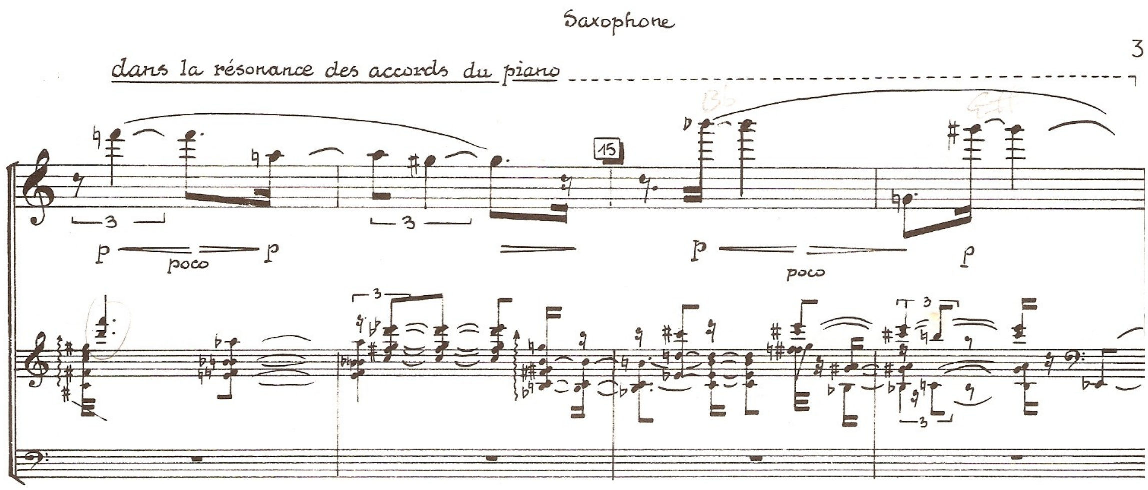
> As the title suggests, the piece does not possess a rigid structure but is an arabesque of different colours which overlap. To this end I have used a very extended range of sound elements, from raw sound to normal playing, both from the saxophone and from the piano. A careful balance is struck between two types of structure: a complex structure, the elements of which are relatively simple and can be analysed by the listener, and a rather simple structure which contains acoustically complex sound elements. These two structures are continually interchanged, and determine the micro-form of the piece
>
> (Nodaïra, 1998)

This straightforward organisation of material allows the performer to prepare the extended techniques in the piece with an idea to their purpose: the transformation of simple lines into complex sounds. It is therefore possible to prepare quarter tones and multiphonic gestures in such a way as to highlight the complex nature of the resultant sound, especially in relation to the piano, which acts as a harmonic 'yardstick' by which the microtonal techniques of the saxophone are highlighted.

Altissimo

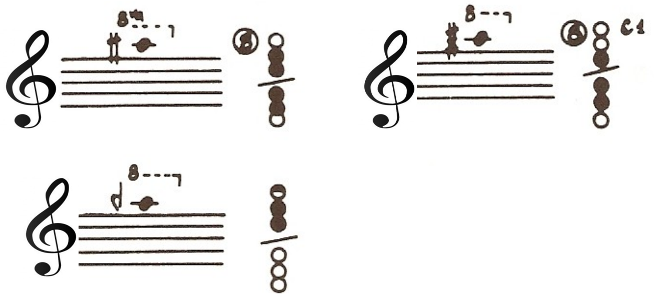
The altissimo register is mostly used in Nodaïra's piece during the simpler material in order to highlight the sonic difference between the saxophone's registers. The first instance of altissimo playing is marked 'dans la résonance des accords du piano' indicating that the tones of the saxophone are to be played as a backdrop to the piano's chords, and so the skill of pitching these notes through use of vocal tract manipulation is of great importance in order to sound these pitches at such a low volume (figure 4.4.1). This style of playing relies heavily on vocal tract tuning in order to avoid a *portamento* effect as the player moves the tongue to the appropriate position, and so the 'heed' tongue position needs to be adopted immediately in order to avoid this unwanted phenomenon. The final section of the piece uses this register extensively alongside multiphonics which also include partials above the normal compass of the instrument. This means that the altissimo register is being used as one of Nodaïra's 'complex sound elements' alongside multiphonics in order to juxtapose the two with interjections from the piano in between the saxophone's line, creating a trio of sound elements. This final section is also the only section in which Nodaïra uses microtones in the altissimo register, and the composer supplies his own fingerings for these notes as

Fig.4.4.1 Ichirô Nodaïra *Arabesque III* (1983) bb.13-16



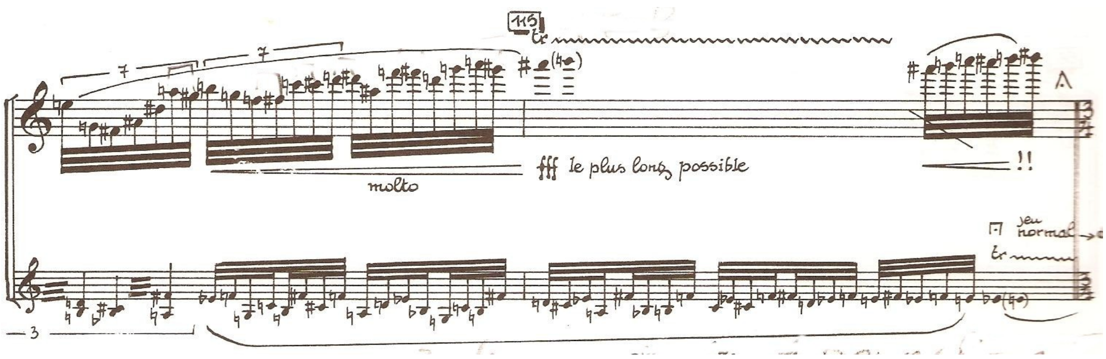
shown in figure 4.4.2. As the altissimo register relies so much on correct tongue positioning, in order to sound the appropriate note, the vocal tract needs to be pitched accurately to these micro-intervals, and as in singing this is notoriously difficult to achieve as the difference in the vocal folds is so slight as to be unreliable. It is therefore important that Nodaïra's fingerings rely on mechanical manipulations to microtonally flatten or sharpen a harmonic note accordingly.

Fig.4.4.2 Nodaïra's microtonal fingerings for the altissimo register



The final use of the altissimo register occurs in bar 115 of the piece where after a more complex passage where the saxophone is playing septuplet demisemiquavers over the piano's demisemiquavers simultaneously, the saxophone ends on a trill between A#6 and B6 which is then followed by a very quick chromatic ascent through the harmonic notes from A#6 to D#7. This group of notes is notated as acciaccatura demisemiquavers as shown in figure 4.4.3 and so the performance of this group needs to be defined in order to present a strong and definite ending to this section. The fingerings for this chromatic scale are straightforward as the normal chromatic fingering from C#6 to F#6 can be used and

Fig.4.4.3 Ichirô Nodaïra *Arabesque III* (1983) b.115



then overblown by a sixth as per Rousseau's method described previously. This is the simplest fingering system for saxophones which have a high F# key. If a saxophone is without a high F# key (my alto does not have this key) then the saxophonist can play the normal fingering from C#6 to F6 overblowing a sixth but then must return to the fingering for D6 and overblow a minor ninth to reach the D#7. This is achieved by moving the tongue through the different positions from the 'head' position when playing A#6 though the 'heed' position when overblowing a sixth and moving finally to the 'hid' position to reach the D#7 without the use of a high F# key. This accuracy of tongue position is very important in this gesture as it is possible to place the tongue incorrectly according to the fingering, and this results in a harmonic *glissando* using the tongue which is not the effect that is required.

It is important that the manipulation of the oral cavity, and especially the tongue, is as accurate as possible when preparing and performing the altissimo passages for Nodaïra's composition. The subtle variances of pitch can accidentally be mis-pitched through incorrect tongue position, resulting in the incorrect note being sounded as the performer has not moved the tongue to the desired position.

Multiphonics

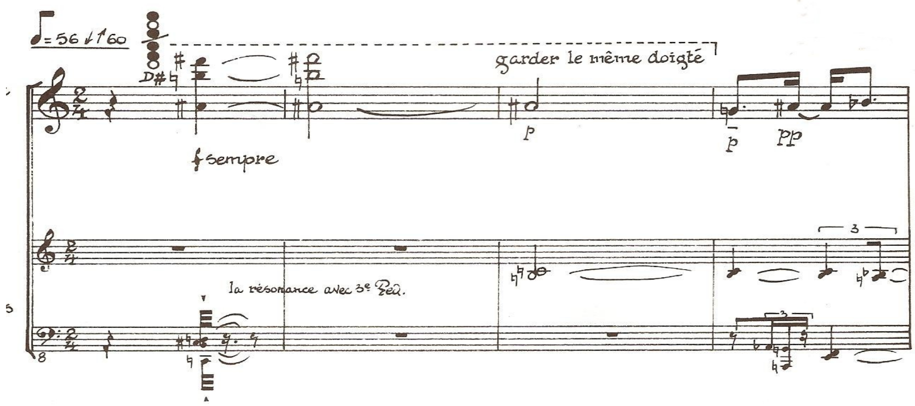
As has been stated, it is Nodaïra's intention to present the listener with a composition that has two clear elements: 'a) a simple structure created from very complex elements which cannot be analysed by the ear. b) a complex structure which can be analysed by the ear with great difficulty and which is created from simple elements' (Nodaïra, 1983). It is within structure 'a' that Nodaïra uses multiphonics as a complex element which, nevertheless, converges with the piano's line. The technique of pitching single notes within multiphonics is used throughout these 'a' sections, and indeed it is this technique that often serves as an anchor point to bring the piano and saxophone together as a homogenous sound.

The first multiphonic of the piece is treated in this way as the full multiphonic is sustained from bar 1 through bar 2 but then the lowest partial is sounded, along with the piano's notes, in bar three in order to create a close cluster chord of three notes each a semiquaver apart as in figure 4.4.4 (track 87). The score shows this B3, C4, C#4 cluster clearly;

Fig.4.4.4 Ichirô Nodaïra *Arabesque III* (1983) bb.1-3 (piano score)

however, when reading the saxophone part this note is written as it sounds: as an A4 a quartertone sharp as shown in figure 4.4.5 (concert C4 quartertone sharp) and so the score does not fully take into account the microtonal nature of the multiphonic partials, and so the resulting sound is harmonically even closer than that of a semitone to the piano's C4. By exploiting the malleability of this multiphonic (Kientzy number 115) Nodaïra uses the saxophone to link gestures together. In this case the *forte* section into the *piano* section without loss of sound. This technique is used again later in the piece where Nodaïra uses the saxophone's

Fig.4.4.5 Ichirô Nodaïra *Arabesque III* (1983) bb.1-3 (saxophone part)



ability to sound the single partial, transforming it into the full multiphonic and then returning to the single partial in order to link sections and to create a backdrop against which the piano plays thus promoting the homogenous sound the composer wants. This is clear in bars 73 to 75 of the work in which the saxophone plays a long multiphonic gesture whilst the piano plays against the full multiphonic (figure 4.4.6). In this section the piano's material in the treble clef often coincides with the notes the saxophone is holding within the multiphonic, for example the chord the right hand of piano plays at the end of bar 73 is made entirely of the notes within the saxophone's multiphonic, and bar 74 uses the pitches C#, D and F# which are enharmonic versions of the saxophone's pitches. It is interesting that this multiphonic as described in Kientzy (2003, figure 4.4.7) notates the partials of this multiphonic (number 119) as having a D#5 rather than, as Nodaïra notates in his piece, D5 natural as shown in figure 4.4.6. Figure 4.4.8, however, shows the resultant notes given in Weiss & Netti (2010) which agree with Nodaïra's version which fits with the piano's material; indeed, in practice, with this multiphonic I can pitch the D5 natural but I

Fig.4.4.6 Ichirô Nodaïra *Arabesque III* (1983) bb.71 – 75

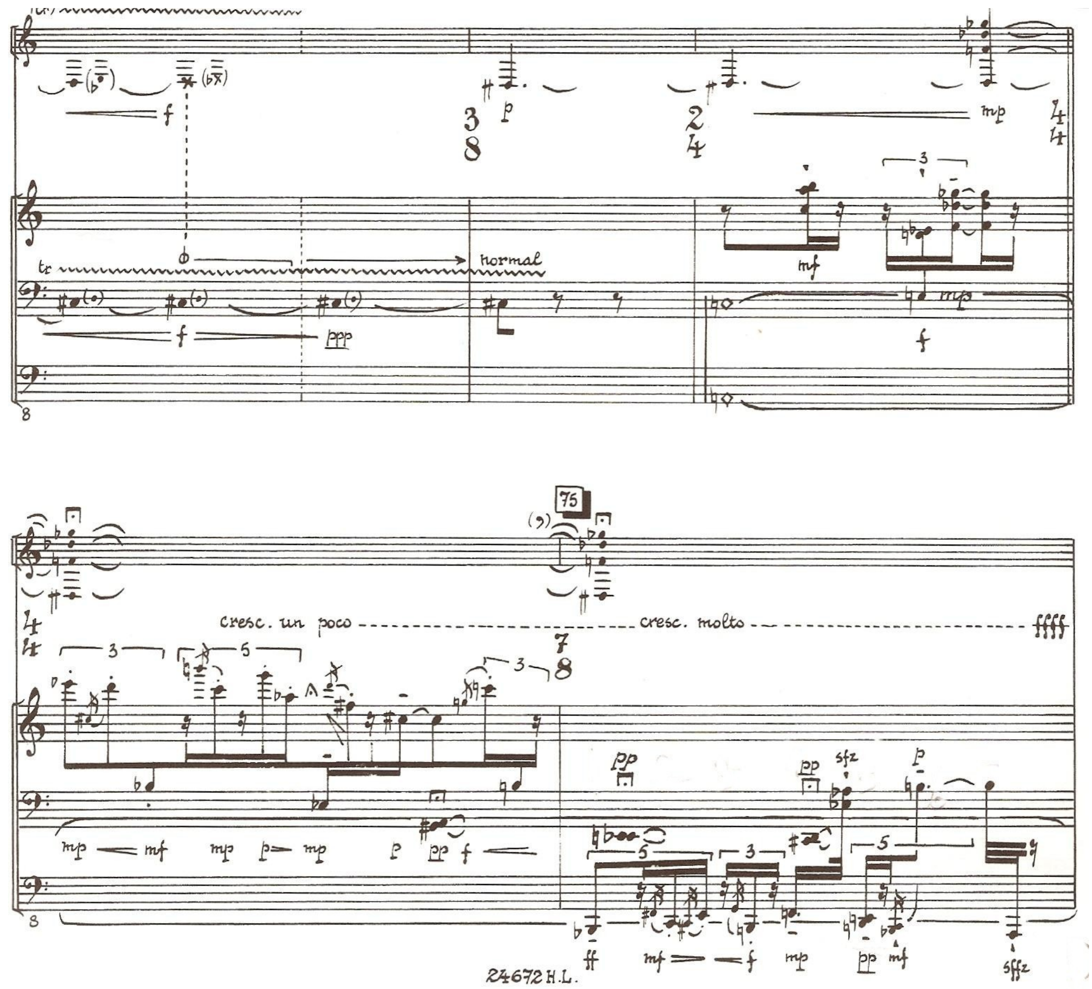
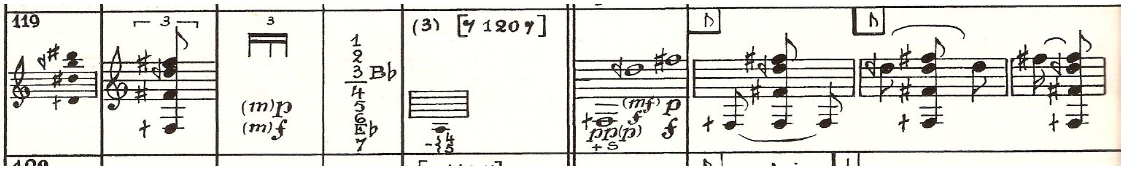


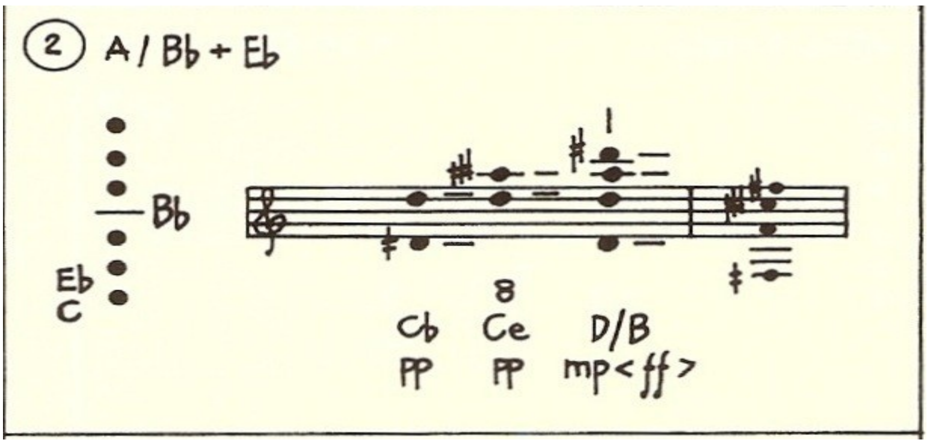
Fig.4.4.7 Kientzy multiphonic number 119 taken from *Les Sons Multiples Aux Saxophones* (2003)



cannot pitch a D#5 using this fingering; this could be due to Kientzy's specific equipment set up and his own individual physiology which results in his ability to pitch this different partial.

Nodaïra uses multiphonic trills at bar 116 (figure 4.4.9) to begin another section of complex sound elements which are split into two groups: type B multiphonics (sound with strong oscillation) used for *forte* passages and type D multiphonics (aggregate of two or more

Fig.4.4.8 Weiss & Netti multiphonic number 2 taken from *The Techniques of Saxophone Playing* (2010)

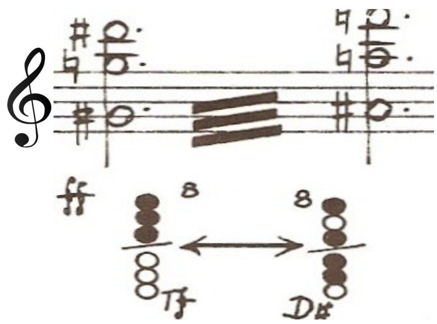


partials over a fundamental) used for *piano* passages (track 88). These two different classifications carry with them two different methods of production. The first group is comprised largely of stable multiphonics which change with the addition of a vent key in order to realise the trill. The 'hawed' tongue position is needed for these multiphonics as they are stable, and the main partials sound strongly, meaning that the addition of the vent key for trilling purposes requires no change of tongue position. The second group, being unstable, require a very specific tongue position in order to sound. The top note of the multiphonic is pitched using the 'heed' position and then this note is 'split' by relaxing the throat to a deep 'who'd' position; an action which feels the same as a descending throat

Fig.4.4.9 Ichirô Nodaïra *Arabesque III* (1983) bb.116 – 121

glissando. This level of specificity creates a delicate sound for these dyads which matches their *mezzo piano* dynamic. The final trill of this section occurs in bar 120 (figure 4.4.10) and it is problematic for a number of reasons. Firstly, the fingerings given by Nodaïra cannot be performed at the speed necessary for a trill as the co-ordination needed to remove the third finger of the right hand from the F# trill key whilst adding the first, second and fourth finger of the right hand at the speed needed to perform a trill is not possible. Secondly both multiphonics within the trill require different tongue positions in order to sound. The first multiphonic acts much like the type D multiphonics we have seen in the previous bars in that the saxophonist is to pitch the top note of the multiphonic and place the tongue in the 'who'd' position. For the second multiphonic the tongue needs to be placed in the 'heed' position and so in order to perform this particular trill the tongue would need to move from one specific position to another at the speed of a trill which is not possible. One solution to this problem can be heard in Claude Delangle's version as recorded on his album *The Japanese Saxophone* (1998) where it can clearly be heard that Delangle plays a trill between two type B multiphonics, the second being the multiphonic fingering as stipulated in the score (track 89). As the fingering for the second multiphonic uses many fingers the most likely fingering chosen by Delangle is the addition of key 6 to the existing fingering which changes the second multiphonic (Kientzy number 115) into a modification of Kientzy multiphonic number 118, maintaining the multiphonic type and timbre which then allows the two to be trilled.

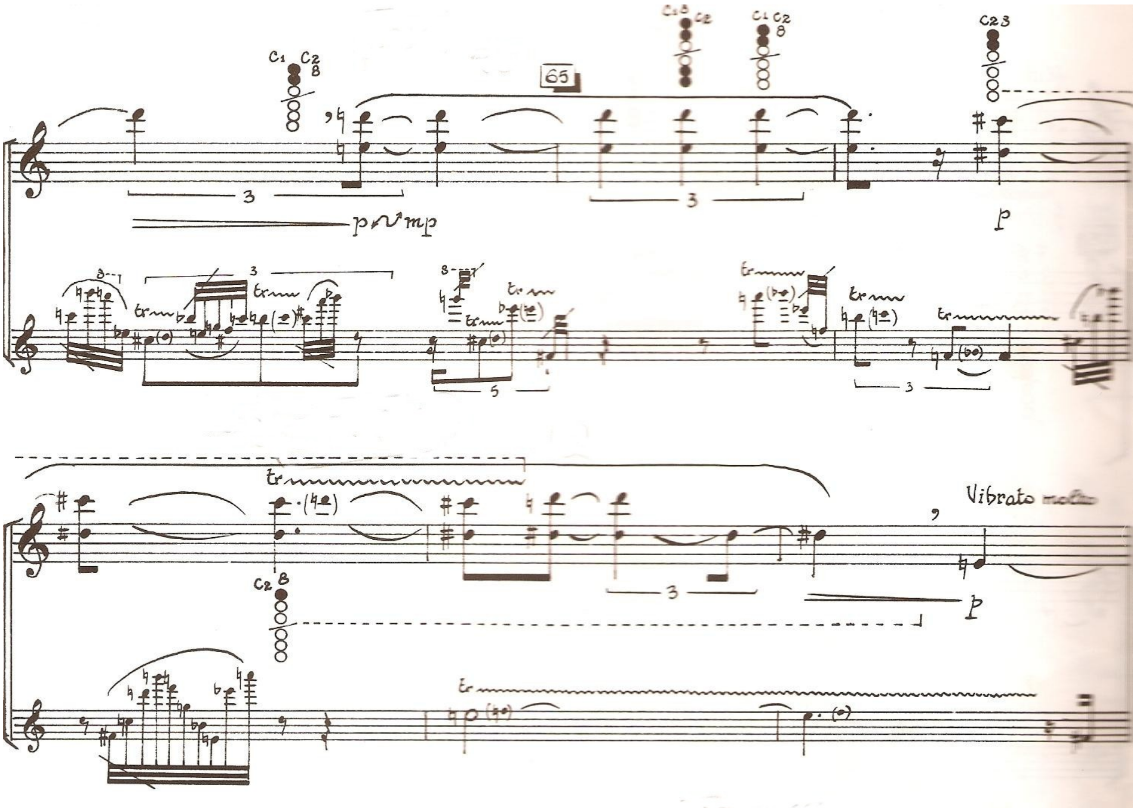
Fig.4.4.10 Ichirô Nodaïra *Arabesque III* (1983) b.120



Nodaïra's use of type D multiphonics as a harmonic backdrop echoes the piano's use of the third pedal in order to sound a general harmonic wash to the piece coming from either the saxophone or the piano and thus further promoting the idea that the two instruments should sound as one. Figure 4.4.11 shows bars 64 to 69 of the score where the saxophone holds dyads whilst the piano plays rhythmic gestures over the top. This promotes the idea of a foreground and a background in these instances within the work and the performance of these dyads can reflect that, as these dyads are unstable and are pitched by 'splitting' a note. They have the characteristic of being delicate and this can be exploited to keep the multiphonic in the background of the sound. This is done by producing the multiphonic using a slow and gentle air stream and using the tongue to split the note under very low air pressure. This technique will keep the pitches of the multiphonic intact whilst making it possible to keep the volume low and to play within the resonance of the piano.

Nodaïra's choice of multiphonics largely correspond with the purpose they serve within the piece, with strongly oscillating type B multiphonics serving as strong gestural material and unstable type D dyads serving to create a harmonic backing to the piano's material; promoting the idea of homogeny. These multiphonics can therefore be produced in specific ways in order to ensure that these roles are fulfilled and to establish the hierarchy of the piano or saxophone being in the foreground or the background as appropriate.

Fig.4.4.11 Ichirô Nodaïra Arabesque III *(1983) bb.64-89*



Bisbigliando

One of the ways Nodaïra presents his idea of complex sound elements is to take a single note in the saxophone part and to treat it in various ways, using alternate fingerings and *bisbigliando* trills alongside double and flutter tonguing to make this single note sonically interesting. Figure 4.4.12 shows bars 49 to 54 of the saxophone part and includes different techniques in the saxophone's line including *bisbigliando* on the note E5 for which Nodaïra suggests adding the C finger to the normal fingering in order to sound the effect (track 90). This addition of a lower key makes a one-finger fork. This flattens the sound so that a deficit of 7Hz is heard. This deficit is the difference between E5 at 392Hz and the alternative fingering of E5 with the added C key which sounds at 385Hz. Figures 4.4.13 and 4.4.14 show the alternate fingering suggestion from both Weiss & Netti (figure 4.4.13, track 91) and Londeix (figure 4.4.14, track 92), and in both cases the addition of extra keys to the normal fingering is the only option possible in this instance due to the speed needed to play the *bisbigliando*.

Fig.4.4.12 Ichirô Nodaïra *Arabesque III* (1983) bb.49-54

Fig.4.4.13 Alternate fingerings for E5 taken from Weiss & Netti (2010)

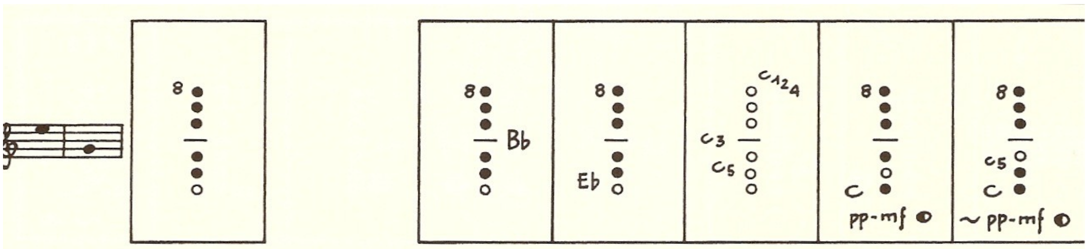
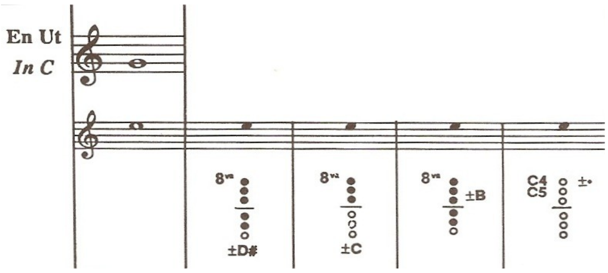


Fig.4.4.14 Alternate fingerings for E5 taken from Londeix (1989)



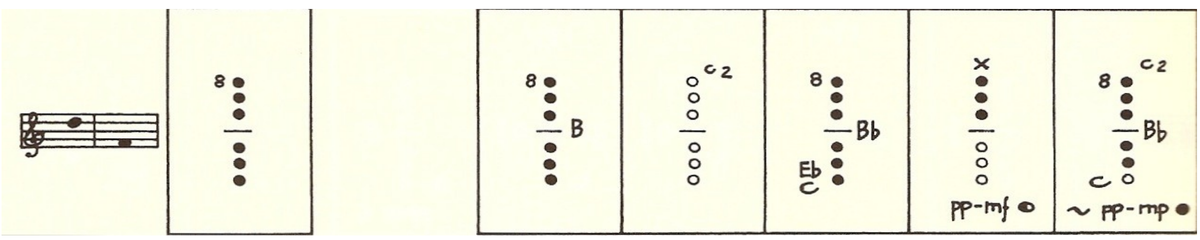
With this in mind, it is suggested that the low B key (Londiex), the low Bb key (Weiss & Netti) or the Eb/D#key (both) be added. All of these alternatives (including Nodaïra's fingerings) can be performed at speed and the following table compares the resultant pitch relative to that of the normal E5 which sounds at 392Hz.

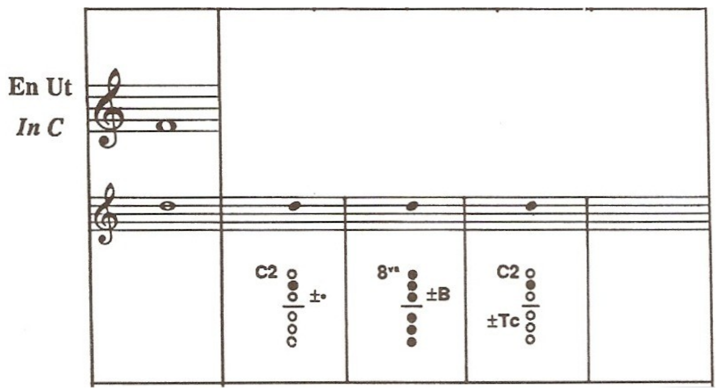
Table 25: Resultant frequencies from playing alternate fingerings for the note E5

	Nodaïra's fingering	Weiss & Netti's fingering	Londeix Fingering	Shared Londeix and Weiss & Netti fingering
Sounding frequency	385Hz	390Hz	391Hz	397Hz
Difference from E5	-7Hz	-2Hz	-1Hz	+5Hz

Although the results from this table indicate that Weiss & Netti and Londeix's fingering alternatives are the closest in Hz to the original pitch, it is probable that if these alternatives were played as a *bisbigliando* then the difference in pitch is so subtle as to be barely audible to the listener and so the effect cannot be detected by the ear. This means that the larger pitch deficit/surplus is preferable for this technique so as to be audible. The shared Londeix and Weiss & Netti fingering (track 93) gives a subtle change whereas Nodaïra's fingering results in a more obvious change in pitch, yet it seems that, with the surrounding material consisting of pitches that have been altered somehow (double tonguing and flutter tonguing), the composer would want the *bisbigliando* to be as close to the original pitch as possible in order to differentiate it from a microtonal trill. For this reason the fingering found in both Londeix and Weiss & Netti (the addition of the Eb key to the normal fingering) is the most appropriate.

Fig.4.4.15 alternate fingerings for the note D5 as taken from Weiss & Netti (2010) and Londeix (1989)





A similar methodology can be applied to the next *bisbigliando* on the note D5 as once again Nodaïra's fingering results in a much wider sonic deficit from the normal note than does Weiss & Netti's and Londeix's suggestions. Figure 4.4.15 shows Weiss & Netti's and Londeix's alternate fingerings, of which only the one which adds the low B key can be played at the speed required. This is different from Nodaïra's fingering which has the saxophonist opening the C# key to achieve the trill, and this hints that whichever of the low keys are opened (low C#, B or Bb) will result in a flattening of pitch in accordance with Benade's open-hole lattice principle. Table 26 displays the resultant frequencies from the addition of each of these keys and the sonic difference in Hz between the alternate fingering and the normal D5 which sounds at 349Hz.

Table 26: Resultant frequencies from playing alternate fingerings for the note D5

Added key (to D5)	Low C# (Nodaïra's fingering)	Low B (Shared suggestion from both Weiss & Netti and Londeix)	Low Bb
Sounding frequency	354	347	344
Difference from D5	+5Hz	-2Hz	-5Hz

Again the table shows that the shared suggestion as found in both Weiss & Netti and Londeix is too close to the normal frequency to be practicable for a *bisbigliando* and so a choice must be made between sharpening or flattening the pitch by 5Hz. It seems appropriate here that as the chosen alternative fingering for the note E5 as shown in table 26 (shared Weiss & Netti and Londeix suggestion) also added 5Hz to the normal sounding frequency then to do the same in this instance and use Nodaïra's fingering will promote consistency for this technique and produce a similar sound for each of the trills.

Nodaïra uses *bisbigliando* as one of a number of ways to change a pitch into a more complex sound element and so the choice of fingering for each instance of the technique is important not only to realise the effect but to retain the sounding of the pitch whilst registering a change of timbre in the listener's ear. The process presented here is one way in which a performer can make fingering choices based upon the sounds that are desired at this point in the composition.

Embouchure Techniques

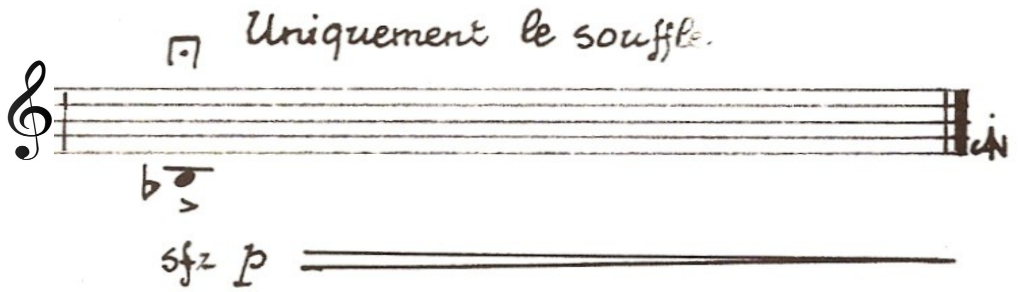
As has already been stated the composer wishes to use an extensive palette of sounds from 'raw sound to normal playing' (Nodaïra, 1998) and so Nodaïra's raw sound elements are achieved through altering the embouchure so as to constrict the air flowing into the instrument and therefore change the sound. This happens during a period of *tremolo* where the score is marked 'le sons apparait progressivement' indicating that the performer is to progressively introduce air into the instrument so that the gesture grows from key sounds ('raw' sounds) to normal playing gradually (figure 4.4.16). This is done by changing the embouchure into the subtone position by withdrawing the bottom lip into the mouth and dropping the jaw so that a little more lip is exposed to the reed thus subduing the vibration. This technique can be sustained for the entire passage, once again promoting the idea of homogeny between the two instruments which are trilling as one in this passage.

The second use of 'raw sound' in the piece comes in the last bar where the composer stipulates a *sforzando* attack with a long *diminuendo* using only air sound indicated by the direction 'Uniquement le souffle' or 'air only'. Nodaïra has indicated that the fingering of Bb3 should be used which closes the saxophone's tube completely thus amplifying the air stream as much as possible, but blowing hard into the mouthpiece with a normal embouchure does not sound a sufficiently strong attack for the dynamic marked (figure 4.4.17). It is therefore necessary to take the top lip away from the mouthpiece and to withdraw the mouthpiece

Fig.4.4.16 Ichirô Nodaïra *Arabesque III* (1983) bb.122-124

slightly from the mouth in order to direct the air stream directly into the gap between the reed and the tip of the mouthpiece. Once the *szforzando* attack has been sounded in this way the player can replace the lips onto the mouthpiece in the normal embouchure shape in order to perform the long diminuendo from *piano* to *niente,* ending the piece convincingly (track 94).

Fig.4.4.17 Ichirô Nodaïra *Arabesque III* (1983) b.153



Key Percussion

Another indication of homogeny between the saxophone and the piano occurs in bar 125 where the composer indicates that the saxophonist should make as many varied key sounds as possible ('Bruits de clés les plus varies possible'). This technique is significant at this point as the piano is trilling on a muted note that has been stopped by depressing the string with the finger; the symbol for this is displayed over the piano line (figure 4.4.18). These two 'complex sound elements' once again promote the composer's intention of one overall sound for this work. Key percussion at this point is, therefore, to be varied from the piano's trill. Using the trill keys on the side of the saxophone is an effective use of key percussion as their location half way down the instrument's tube makes them resonant enough to be heard and they can be used at higher speeds. Keys lower down the instrument, however, result in a more resonant sound but are not as easy to play quickly. The palm keys at the top of the instrument do not produce much sound as there is little of the tube to reSonata in. As the composer wishes to hear 'as many varied key sounds as possible' a mixture of each type of key sound can be experimented with in this section, bearing in mind the sound coming from the piano and the homogeny that is to be maintained. The more resonant keys at the bottom end of the instrument are therefore to be used sparingly as it is easy for these notes to overpower the piano's muted trill therefore bringing the saxophone into the foreground and not conforming to the piece's homogeny.

Fig.4.4.18 Ichirô Nodaïra *Arabesque III* (1983) b.125

Flutter Tongue

Alongside *bisbigliando* trills Nodaïra uses flutter tonguing, another technique by which the simple material can be altered to create a complex sound. The use of flutter tongue throughout *Arabesque III* is often surrounded by other changes of timbre such as double tonguing a single note or a *bisbigliando* on a single note in order to highlight the sonic change of these simple pitches. Figure 4.4.19 shows bars 49-54 of the saxophone part, a passage in which this behaviour is apparent. In this section the saxophonist has to move quickly between the tongue position necessary for double tonguing and the hard palate position needed to facilitate the tongue flutter technique. If the throat flutter technique is used it negates the need for this awkward tongue movement whilst still presenting the listener with a sufficiently audible disturbance of the air column. This technique does not work as well when the flutter technique is sounded at the same time as a second sonic disturbance such as a multiphonic (figure 4.4.20). In this instance the throat flutter does not create as strong a sound as the tongue flutter and so it cannot be heard over the secondary technique; therefore, the tongue flutter will be more audible at these points.

Fig.4.4.19 Ichirô Nodaïra *Arabesque III* (1983) bb.49-54

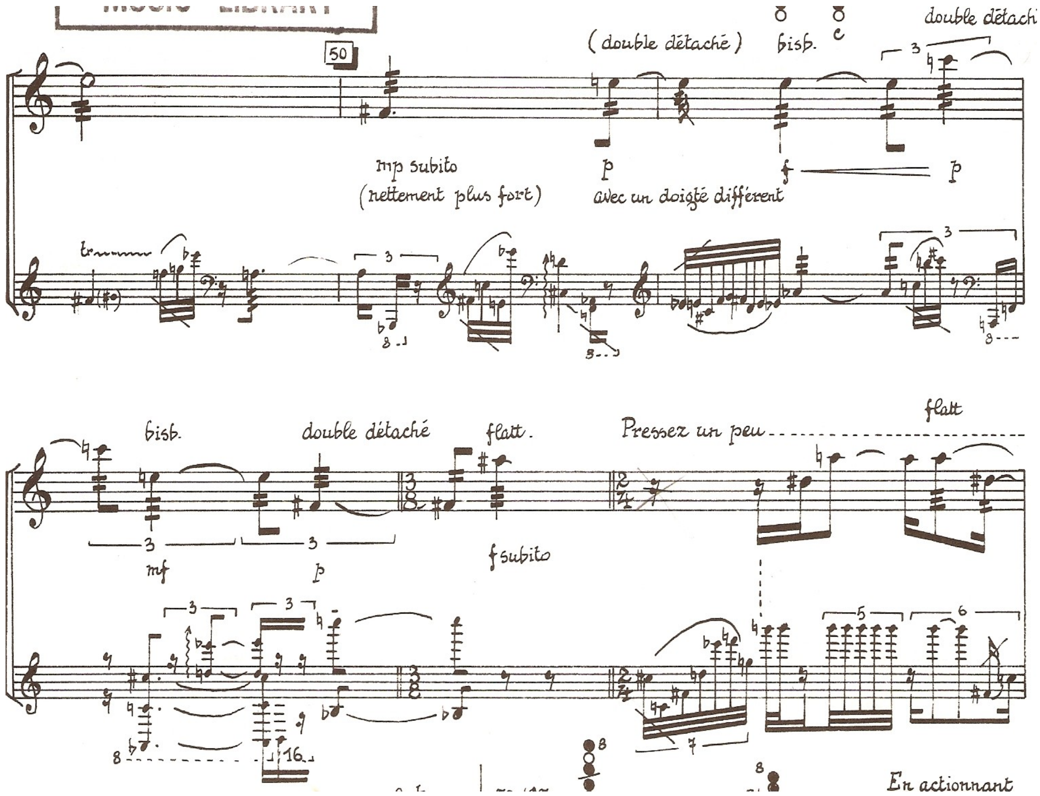


Fig.4.4.20 Ichirô Nodaïra *Arabesque III* (1983) b.82

Slap Tongue

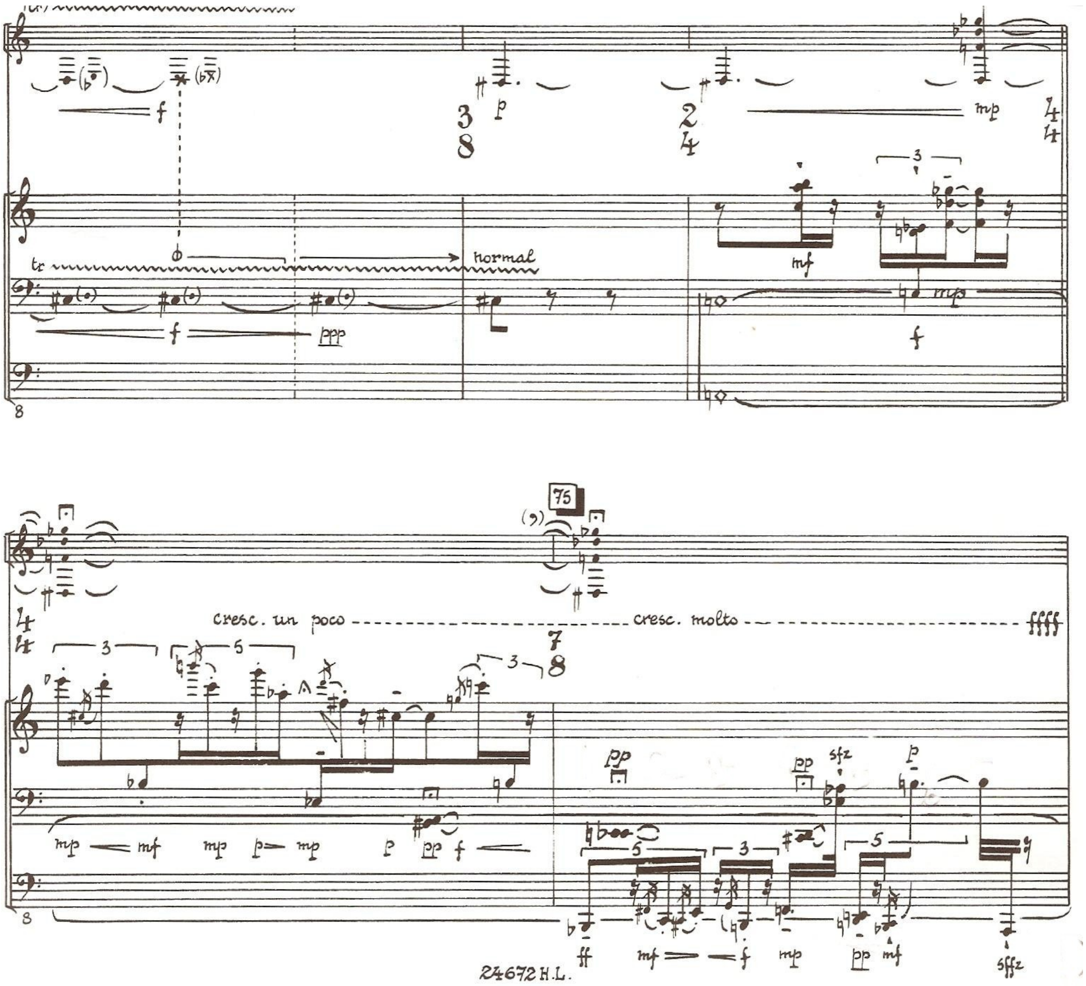
The saxophone's slap tongue effect is used throughout Nodaïra's composition to echo the piano's technique of string damping; the instruments use these techniques independently until bar 77 where the two instruments converge to play this percussive effect (figure 4.4.21). Again, to promote Nodaïra's notion of a homogenous sound, it is important that these two technique are performed so that they are sonically very similar. This can be achieved by the saxophonist performing the slap in the normal way but adding a little air into the instrument, creating an effect which is half way between Weiss & Netti's normal slap, which is fully pitched or even sustained, and a *secco* slap which is a dry un-pitched effect (Weiss & Netti, 2010). By adding a tiny bit of air to the *secco* slap the saxophonist can achieve a dry slap, within which the pitch resonates, thus mimicking the stopped string of the piano with its attack and minimal, yet inevitable, decay (track 95).

Fig.4.4.21 Ichirô Nodaïra *Arabesque III* (1983) piano score b.82 (saxophone part at the top)

Circular Breathing

It cannot be said that circular breathing is a technique Nodaïra exploits in any significant way in this piece but the technique can be used in order to facilitate his notation during a particular moment in the work. Figure 4.4.22 shows bars 71-75 of *Arabesque III* during which the piano plays solo material against the backdrop of the saxophone's held multiphonic which starts as the lowest partial, sounded alone, before the tongue moves in the normal way for the whole spectrum of partials to sound. Depending on the pianist's realisation of the triangular and square *fermata* markings, (meaning medium and long pauses respectively), this multiphonic is to be held longer than a normal lung-full of air can sustain. Circular breathing is necessary, therefore, so as not to break the sound during this moment (the composer acknowledges this by adding a bracketed breath comma half-way through the multiphonic indicating that the saxophonist may take a breath if necessary). There is a problem with circular breathing during multiphonics. The tongue needs to be in the specific 'who'd' position for the multiphonic to sound, yet, the act of circular breathing requires the tongue to adopt the 'hid' position in order to push the air forward in the mouth, maintaining the pressure required to sound the pitch, whilst at the same time retaining contact with the soft palate thus sealing the rear of the oral cavity so that air can be inhaled through the nose. The only option available therefore is to circular breathe on the solo partial in bars 72 and 73 and then to move the tongue into the required position at the end of bar 73 to ensure the full multiphonic sounds. By approaching the gesture in this way a player can ensure that they have sufficient air in their lungs at the end of bar 73 to sustain the multiphonic throughout the piano's solo material in bars 73 to 75.

Fig.4.4.22 Ichirô Nodaïra *Arabesque III* (1983) piano score bb. 71-75



Section 5

Scott Mc Laughlin *Neither Wholes nor Parts* (2010) For Alto Saxophone

The inception of the piece *Neither Wholes nor Parts* (2010) by Scott Mc Laughlin came about through the demonstration of a technique which involves a mixture of both multiphonic production and the manipulation of partials within that multiphonic. This mixture of techniques led to an open improvisation piece for saxophone and laptop entitled *Whitewater* (2007), in which the saxophonist acted as duo partner with a max/msp patch running an artificial life matrix based upon cellular automata. The upshot of this pairing is that the composition which uses an input/output max/msp patch and has the saxophone's multiphonics triggering similar pitches in the patch which then (in theory) could be further reacted to by the improviser turning a basic in/out relationship between saxophonist and computer system into a symbiotic relationship. The stasis of this quasi-composition was then to be captured in Mc Laughlin's next composition using this technique *Neither Wholes nor Parts* for which the composer developed a specific notation based upon the behaviour of multiphonics. The two types of multiphonic that the composer preferred were, to use Weiss and Netti's classifications: type E – narrow dyad and type D/B – Wide multiphonic, usually built on a minor ninth (also second), partly oscillating (Weiss & Netti, 2010). These multiphonics had the sound and the level of manipulation that the composer wished to use throughout the piece; the notation system that was therefore adopted is explained by the composer as follows:

> stave: the three lines are the lowest and highest pitches available, the middle is notionally the middle of the instrument range but depends on multiphonics chosen, this is very flexible.
> Notes that appear contiguous should have the same pitch. Where a normal note follows a partial at the same visual height an appropriate microtonal fingering may be needed to maintain pitch parity; subtle microtonal deviations are expected.
> Avoid the extremes of high register unless very quiet and stable.
>
> Vertical dashed lines indicate a fingering change, all multiphonics between a given set of dashed lines should be performed with the same fingerings

> noteheads: white/open are multiphonic partials, black/closed are standard fingered pitches.
> Single open noteheads are a sngle partial from a fingering.
> Two or more vertically stacked white noteheads are a chord but necessarily a full bloom of the multiphonic; they should be separate percepts.
> A single vertical open note covering the whole register is a full bloom of multiphonic, a single percept. Not individual partials.
> Parentheses: notes in parentheses should only be vaguely perceivable, the slightest hint.
> Dashed noteheads: indicate a halo of multiphonic sound, a full percept but only barely more than a partial.
> X-noteheads: indicate short unpitched breath attack.
> Time is relative: un-stemmed notes are long; stemmed are shorter and more gestural; beamed are fast.
> If the player can circular breath smoothly then these can be much longer, though no more than a minute per event.
> Dynamics should be mostly as quiet as is possible to produce (relatively) stable multiphonics.
>
> (Mc Laughlin, 2010)

In this legend of the notational system Mc Laughlin makes regular reference to the music being 'perceived' as musical events, giving the impression of a semi-improvised and static piece with detail within each gesture by treating them as multiphonic events and in this way *Neither Wholes nor Parts* is a microcosm of the preceding compositions.

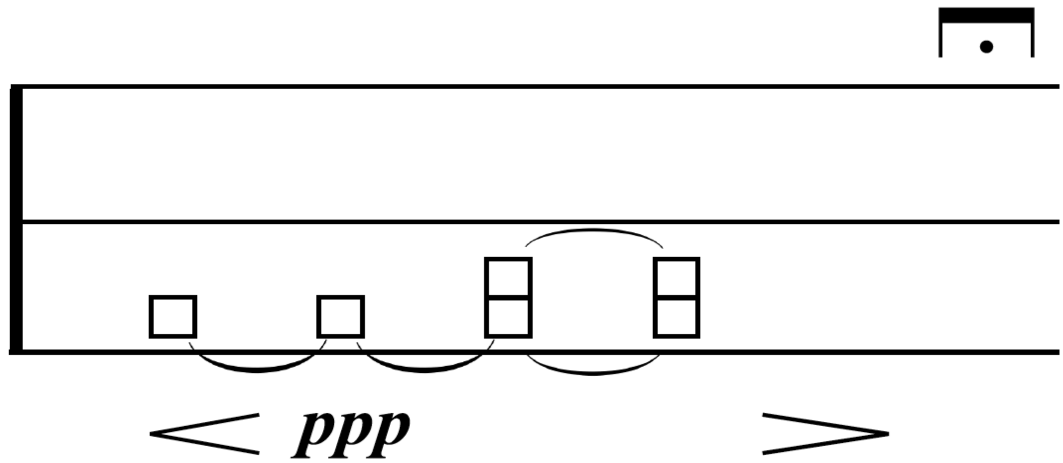
One of the key features of this work is that each performer chooses the multiphonics that they deem best to fit the gestures within the piece. This choice relies on a number of factors: does the multiphonic lie within the register the composer wants? Does the multiphonic behave in the way the composer wishes it to? Does the the multiphonic share a common note with others around it for linking passages?

It is the performer's task to choose their multiphonics that not only fulfil these criteria but behave in such a way that makes them performable according to the specific performer's physiology and experience.

Multiphonics

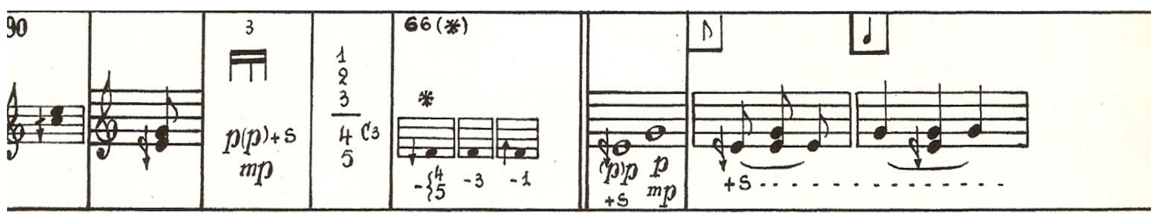
As this piece is predominantly written for multiphonics it seems pertinent to describe the multiphonics I have chosen to play the piece, and to outline why these multiphonics are appropriate. The multiphonic I have chosen to begin the piece with is a narrow dyad comprising the notes C5 a quarter tone flat and E5 (type E, figure 4.5.1). This multiphonic is identified in Kientzy's book as number 90 which also informs us that one is able to separate the pitches but there will be some air noise (+S) present as shown in column three of figure 4.5.2. Kientzy #90 is also a quiet multiphonic with the separated pitch C2 quarter tone flat only

Fig.4.5.1 Scott Mc Laughlin *Neither Wholes nor Parts* (2010) page 1 line 1



executable at *pianissimo* dynamic level. In practice the saxophonist needs to form a subtone embouchure in order to achieve this separation, moving the jaw forward and exposing more lip to the reed suppressing the vibration. In this position the lower partial of Kientzy

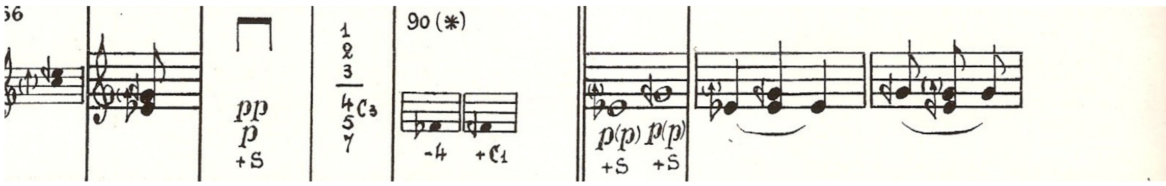
Fig.4.5.2 Kientzy multiphonic number 90 taken from *Les Sons Multiples Aux Saxophones* (2003)



multiphonic number 90 becomes stable and so the player is able to circular breathe this note to give it the longevity the score demands. Once the player has performed the opening of this gesture the lip can be returned to its ordinary playing position to execute the full dyad (track 96). The physical manipulation of the embouchure in this instance allows the multiphonic to 'bloom' as the composer intends, in an unbroken and gradually developing gesture. To isolate the upper partial of this same dyad as is required in the second gesture one must adopt the 'Who'd' tongue position where the tongue is raised toward the soft palate at the rear of the oral cavity. This suppresses the lower partial as it essentially treats the upper partial as a harmonic of the first, isolating it as we do with fundamental tones. With a little practise these minor alterations of embouchure and tongue position give the player the control they need when playing dyads throughout this piece.

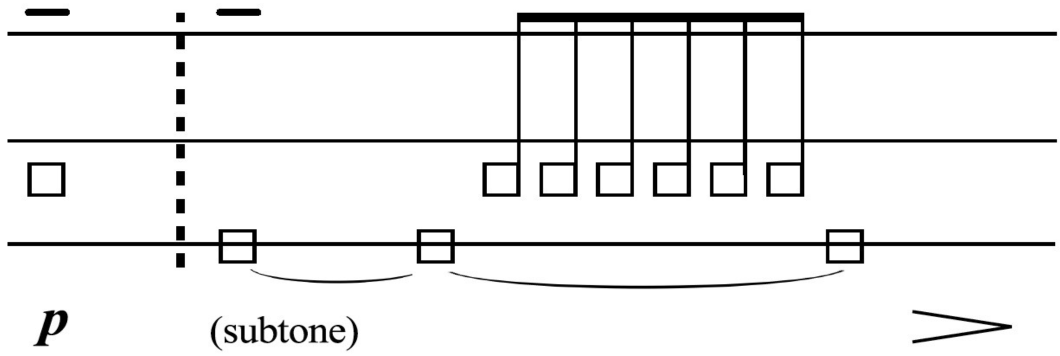
The second dyad used is Kientzy number 66 (figure 4.5.3) and the reason I have chosen this to be the second dyad is twofold: firstly, it is comprised of the pitches C5 and E5 a quarter tone flat which is very close to the pitches of the first dyad and therefore occupies

Fig.4.5.3 Kientzy multiphonic number 66 taken from *Les Sons Multiples Aux Saxophones* (2003)



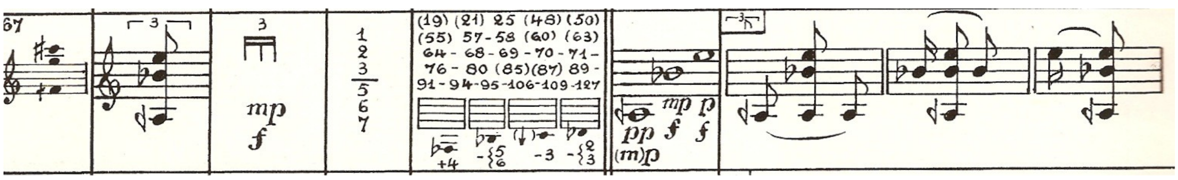
the same space on the stave, and secondly, the fingering of this second dyad differs from Kientzy multiphonic number 90 only in the addition of key 7, making for a smooth change from one to the other. Fingerings that progress cleanly from one multiphonic to the other deserve consideration when maintaining the sounds of the gestures in this piece, and multiphonics of similar types are generally played together within an event to achieve this. The end of line two of *Neither Wholes nor Parts* introduces a new gesture for the piece where the device of sustaining a lower fundamental, yet playing a rhythm over the top of this sustained tone, is used (figure 4.5.4). For this effect I have chosen a multiphonic of type D/B which includes a partial oscillation that helps to separate the tones

Fig.4.5.4 Scott Mc Laughlin *Neither Wholes nor Parts* (2010) page 1 line 2



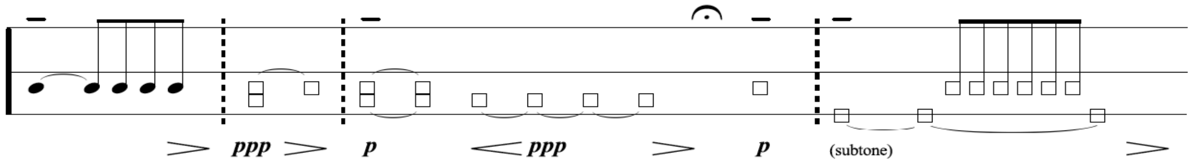
of the multiphonic out from one another and uses the oscillation itself to create the pulsing effect required. Kientzy number 67, being larger than a dyad, lends itself to multiple manipulations, firstly sounding the lowest fundamental only using subtone in much the same way as numbers 90 and 66 have been manipulated previously. Secondly, by forming the 'Head' tongue position the player can sound the lowest note F4 quarter tone sharp and the G5 simultaneously, and also if the tongue is pushed even further forward in the mouth the player can also isolate the G5 and play it as a harmonic from the multiphonic fingering as shown in Kientzy's diagram (figure 4.5.5). Forming the 'heed' tongue position pushes more tongue towards the hard palate at the front of the mouth and it is by doing

Fig.4.5.5 Kientzy multiphonic number 67 taken from *Les Sons Multiples Aux Saxophones* (2003)



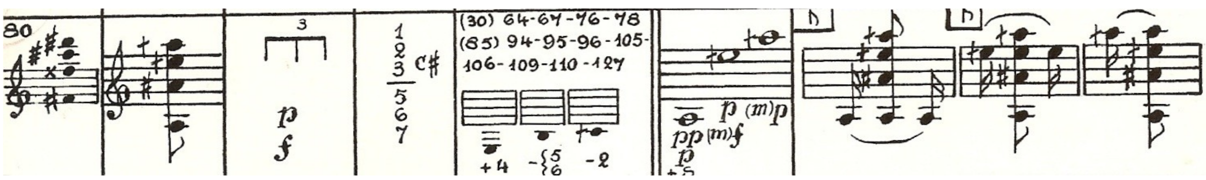
this that the saxophonist can isolate C#6, the highest note of the multiphonic. The full multiphonic on this fingering is sounded by adopting the normal tongue position 'Hawed', making it as stable as a normal tone. It is a mixture of using subtone to isolate the lowest note and repeatedly raising and lowering the tongue in and out of the 'Head' position that the player is able to achieve the effect the composer wishes of a pulsating sound over a sustained single note (figure 4.5.6, track 97).

Fig.4.5.6 Scott Mc Laughlin *Neither Wholes nor Parts* (2010) page 1 line 2



This technique is also used later in the piece, but this time in reverse; the highest note of the multiphonic is sustained whilst the lower partials are sounded as dashed noteheads which are barely audible instances of the multiphonic that the composer describes as a 'halo' of sound. For this gesture I have chosen Kientzy number 80 (figure 4.5.7) which is a similar D/E type to number 67 but is comprised of a minor ninth plus an minor sixth plus a fourth making it a four-note multiphonic. Kientzy's chart depicts the very effect the composer wants to achieve in the far right of the table, informing us that it is possible to sound the F5 three quarter tones sharp individually and to be able to bring in the other partials beneath it. This is done by the saxophonist by reversing the manipulation of number 67; starting in the 'heed' position and slowly relaxing the tongue into the 'Hawed' position

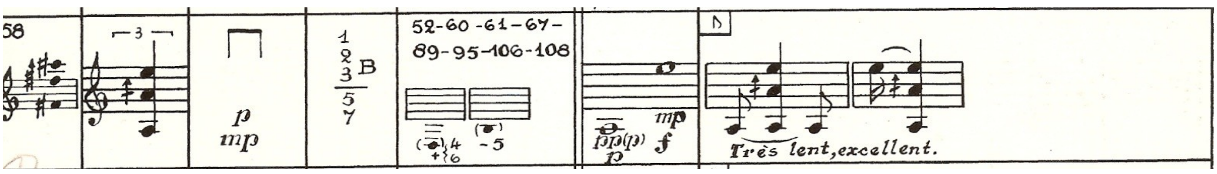
Fig.4.5.7 Kientzy multiphonic number 80 taken from *Les Sons Multiples Aux Saxophones* (2003)



to sound the complete multiphonic. As the composer wants only a hint of sound for the multiphonic 'halo' the player needs to ensure that this tongue movement is as slight as possible. It is this element of control that the composer wishes to exploit throughout this work.

Grouping multiphonic fingering types together is necessary on the second page of the work where the gesture becomes slightly more complex. At the end of the second line of page two the saxophonist needs to find a mid-range partial to isolate which blooms into a multiphonic and ends up as a high-range partial. This high range partial is then switched to a different multiphonic by the dashed vertical line, but as the composer tells us 'Notes that appear contiguous should have the same pitch' and so as the highest partial is held the fingering must change. This is why I have chosen to use Kientzy number 67 with which to start the phrase and, by removing key 6 and adding the low B key, one can change to Kientzy number 58 (figure 4.5.8) without disturbing the upper partial. This is achieved in the normal way of starting the tongue in the 'Hid' position, moving through the 'Hawed' position and then moving quickly to the 'Heed' position.

Fig.4.5.8 Kientzy multiphonic number 58 taken from *Les Sons Multiples Aux Saxophones* (2003)



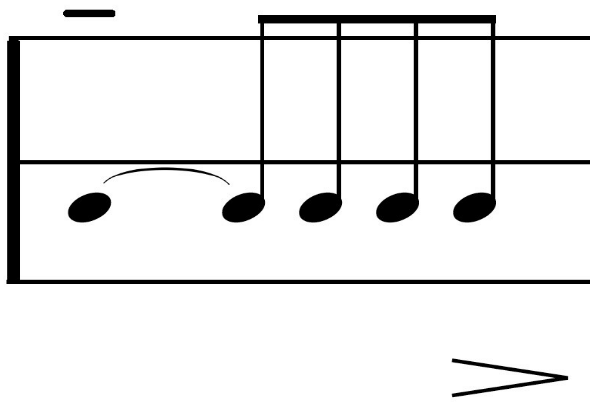
Whilst maintaining this position the saxophonist can change the fingering without affecting the held upper partial before reversing the process and returning to the 'Hawed' position to sound the new multiphonic and back to the 'Hid' position to complete the gesture.

Pitch Techniques

One of Mc Laughlin's influences is spectral music, and the extensive use of multiphonics throughout *Neither Wholes nor Parts* follows this interest as partials are juxtaposed with a 'standard fingered pitch' in order to highlight the timbral difference between them. However, these fundamental tones are often juxtaposed with the complex upper notes of the multiphonics and these by their nature are usually de-tuned from the tempered scale. In order to highlight only a timbral and not a pitched difference, it is necessary to use quarter-tones to match as closely as possible the partial which has been isolated. This practice of pitch-matching isolated tones from each multiphonic demands an intimate knowledge of the multiphonic by the performer alongside a reliable and consistent technique in order to reproduce the same quarter-tonal partial in each performance.

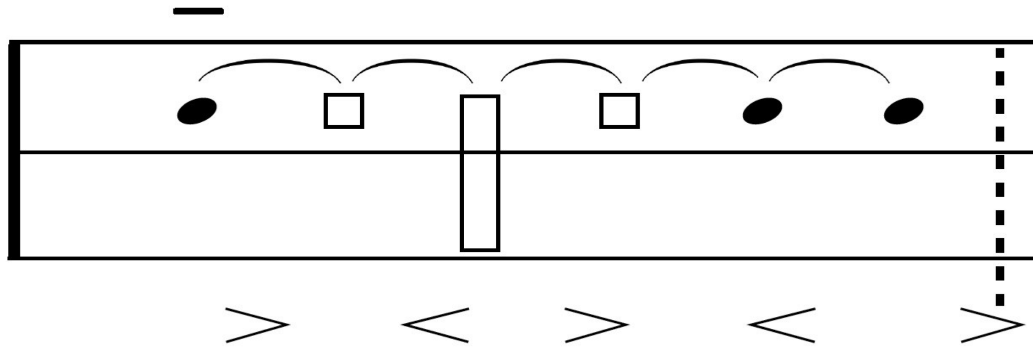
Most of these instances in the score occur alongside the multiphonics I have described above and so it is through a knowledge of these multiphonics that the performer can prepare the appropriate micro-tonal notes to achieve the juxtaposition. Kientzy's chart indicated the upper note of the dyad to be E5 and in the case of Kientzy multiphonic number 90 (figure 4.5.2) when the 'standard fingered pitch' is played its tonal quality is indeed only fractionally different from that of the partial, albeit, slightly brighter in pitch. As the fingering for the note E5 is located far down the length of the instrument there are not sufficient opportunities to flatten the pitch using the keys that lie beneath the E5 tone hole and so the pitch is played as a regular E5 when performing the gesture as shown in figure 4.5.9.

Fig.4.5.9 Scott Mc Laughlin *Neither Wholes nor Parts* (2010) page 1 line 2



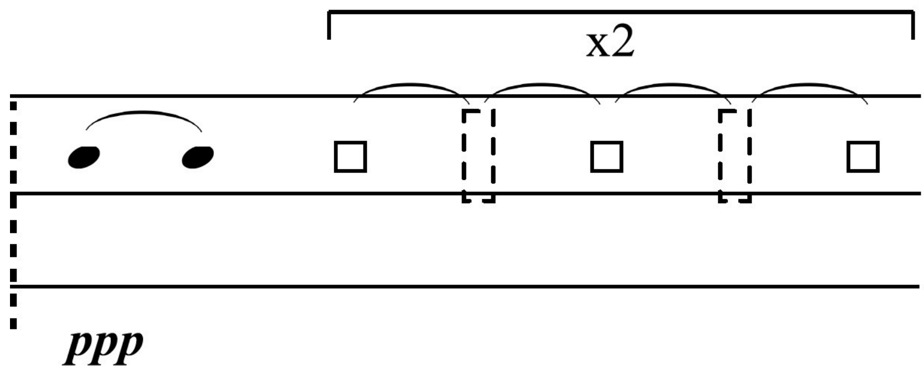
In contrast the highest partial of Kientzy multiphonic 67 is indicated in his chart as being the note C#6 whereas when the partial is isolated from the whole multiphonic, it is clear that the partial is fractionally brighter in pitch than the regular fingered tone. As the note C#5 is high up the instrument's tube (in fact it is an open note with the addition of the octave key) the most effective way to raise the pitch to that of the partial is to open the second octave pip through the addition of the third finger. This vent fingering is often used to regulate the unreliably sharp C#4, smoothing the transition over the break, and is a useful way to match the two pitches in this instance (figure 4.5.10) where a change of timbre but not of pitch is desired.

Fig.4.5.10 Scott Mc Laughlin *Neither Wholes nor Parts* (2010) page 1 line 5



Kientzy multiphonic number 80, which I have chosen for the gesture in figure 4.5.11 due to its matched highest partial with the preceding multiphonic, has the note C6 three quarter tones sharp as its top note when played as a partial. Weiss & Netti (2010) contains the fingering for this note that matches the resultant sound from the previous multiphonic, and the fundamental pitch and harmonic pitch can both be played whilst retaining the same specific frequency, as the composer wishes.

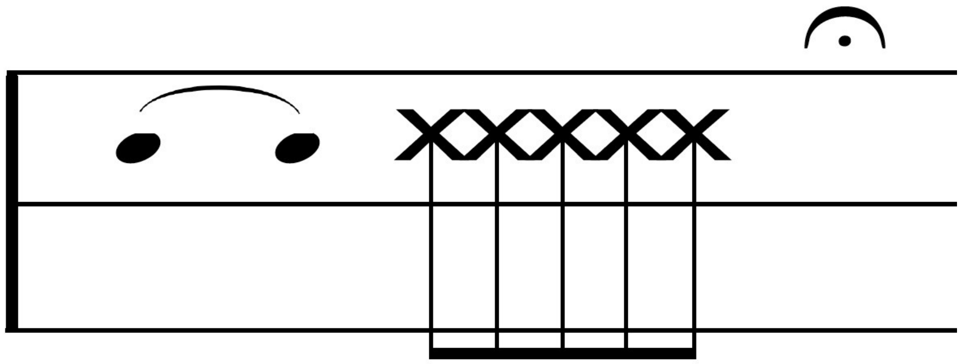
Fig.4.5.11 Scott Mc Laughlin *Neither Wholes nor Parts* (2010) page 1 line 5



Slap Tongue

The composer tells us in his performance directions that an x-notehead indicates a 'short unpitched breath attack' (figure 4.5.12). When working with the composer directly, however, it becomes apparent that a strong tongued articulation is required for this technique, akin to Weiss & Netti's *secco* slap tongue effect but at extremely low volume. This technique is achieved by applying only the tip of the tongue to the reed and using that portion of the tongue to form a vacuum on the reed and, when pulled away, create the slap shown in figure 4.5.12 (track 98).

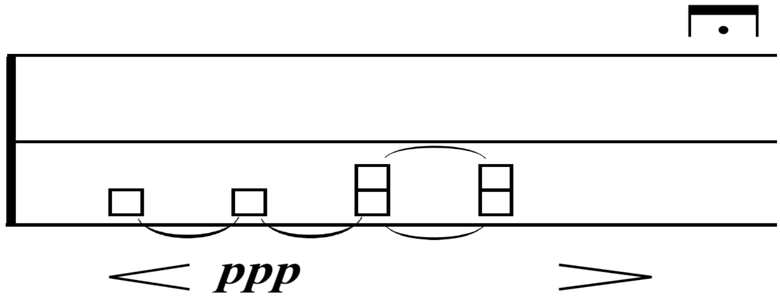
Fig.4.5.12 Scott Mc Laughlin *Neither Wholes nor Parts* (2010) page 2 line 1



Circular Breathing

In relation to the temporal aspect of the composition the composer tells us in his performance directions that 'time is relative: un-stemmed notes are long; stemmed are shorter and more gestural; beamed are fast. If the player can circular breathe smoothly then these can be much longer, though no more than a minute per event' (Mc Laughlin, 2010). This open invitation for circular breathing serves to heighten the dramatic tension of each gesture by drawing it out over a longer period of time; however, the problem of tongue placement whilst playing full multiphonics is again present as the tongue is needed during the act of circular breathing to keep the air pressure of the air caught in the cheeks sufficiently high so as to sound the pitch. The solution to this problem is to circular breathe on the low fundamental notes either side of the full multiphonic, resulting in the overall phrase being longer but the full multiphonic being unbroken by movement of the tongue. This technique can be applied in all of the instances of this gesture throughout the piece especially the first and last which include un-stemmed lower partials with ties making them very long as depicted in figure 4.5.13.

Fig.4.5.13 Scott Mc Laughlin *Neither Wholes nor Parts* (2010) page 1 line 1



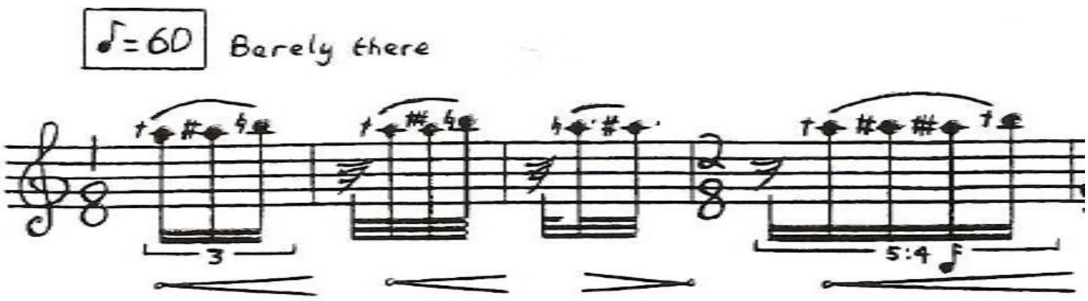
Section 6

Ben Isaacs *I Never Look Like Myself* (2009) For Soprano Saxophone

The music of Ben Isaacs has a strong character in that the composer is interested in the relationship between sound and silence and in particular the threshold that separates these two states. To this end Issac's music is typically written within a confined spectrum at the lowest end of the instrument's dynamic range, with the lowest dynamic usually being *niente* and the highest dynamic possibility being, in the case of this composition, 'barely there'. Isaacs also writes crescendo and diminuendo markings between either end of the range. This style of composition highlights a tension between silence and sound, and puts the performer under pressure to constantly asses the balance between audible sound and in-audible gesture following the contours of the composer's crescendo and diminuendo markings. The benefit of writing for a wind instrument in this case is that the player is able to gradually introduce sound by gradually increasing air into the instrument through their control of the air column they introduce into it, which allows for an almost infinite gradation of sound from silence, to air sound, to un-pitched air sound, to pitched air sound, and so on until the lowest volume of the pitch is heard.

The composer states at the beginning of the score that 'It could perhaps be argued that the score is in this case rather unrepresentative of the sounding result; one encounters two pages of continuous microtonally ascending scales underpinned by smooth dynamic hairpins, and whilst in performance there is a clear sense of upward motion, the sounding result is far more fragile and sporadic than the score might initially suggest' (Isaacs, 2009). This highlights another tension within the piece (which has conventional notation, figure 4.6.1), resulting in a rather unconventional sound (track 99). This tension is apparent in hearing the piece as the performer struggles to keep the notes from sounding until the top of each hairpin, resulting in the sounding of different sections of the microtonal material in each performance. The composer himself states that 'The aim when adopting such techniques is to create a volatile and dynamic performance situation in which the tactility of the sound and "live-ness" of the performer's actions is an integral part of the musical experience' indicating that an element of chance is inherent in the production of these dynamics and that he wishes to exploit the transient nature of a performance in order to ensure that one performance differs from the next.

Fig.4.6.1 Ben Isaacs *I Never Look Like Myself* (2009) movement I bb.2-3



Microtones

Regarding the microtonal nature of the piece the composer states 'I use microtones as a way to enhance the intricacy and intimacy of the music rather than to build specific harmonic structures. My pieces invariably operate in very compressed musical spaces, and constricting the intervallic content of the music certainly aids the construction of this aspect'. This statement reinforces Isaac's overall aesthetic of 'compressed musical spaces' in harmony and dynamic, but also duration as each of the four movements in the piece are between 16 and 18 bars long.

The musical space in the case of this piece is compressed between the notes A5 and D6 quartertones sharp, with microtonal increments filling up the space in between. The following table shows the exact microtones that are used in *I never look like myself* (2009):

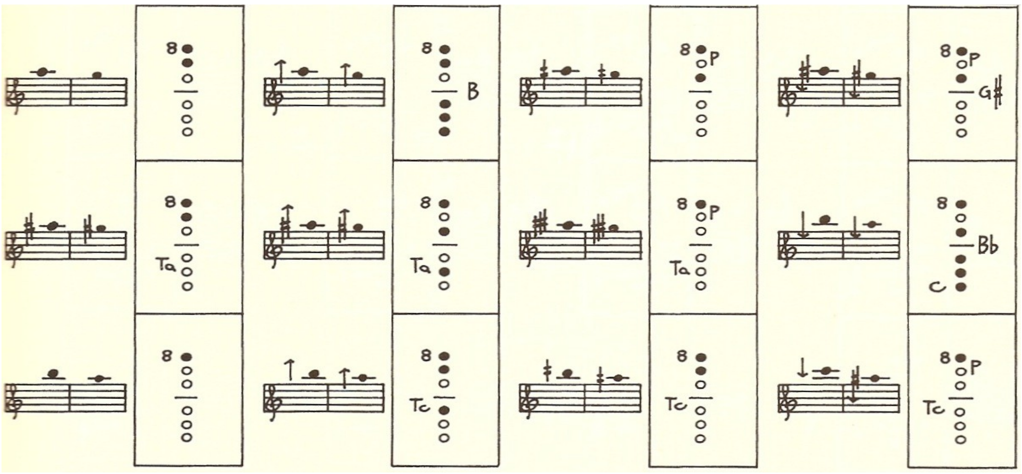
Table 27: List of microtones that are used in Ben Isaacs *I Never Look Like Myself* (2009)

A5
A5 quartertone sharp
A#5
A5 three quartertones sharp
B5

B5 quartertone sharp
C6
C6 quartertone sharp
C#6
C6 three quartertones sharp
D6
D6 quartertone sharp

It is interesting that each microtone in the piece is written as a sharp rather than a flat and indeed no enharmonics are used at all, this indicates that, as the pitch is constantly rising, each microtone is to be as close to the normal pitch as possible so as to compress the sonic space as much as possible. In order to achieve this effect the different fingering suggestions for these microtones need to be explored for their sonic proximity to the normal pitch, and it is this information which aids my choice of fingering throughout the piece. Figure 4.6.2 shows the fingering suggestions from Weiss & Netti for pitches in between these two notes and figure 4.6.3 shows Londeix's suggestions.

Fig.4.6.2 Fingering suggestions for microtones between the notes A5 and D5 quartertone sharp taken from Weiss & Netti (2010)



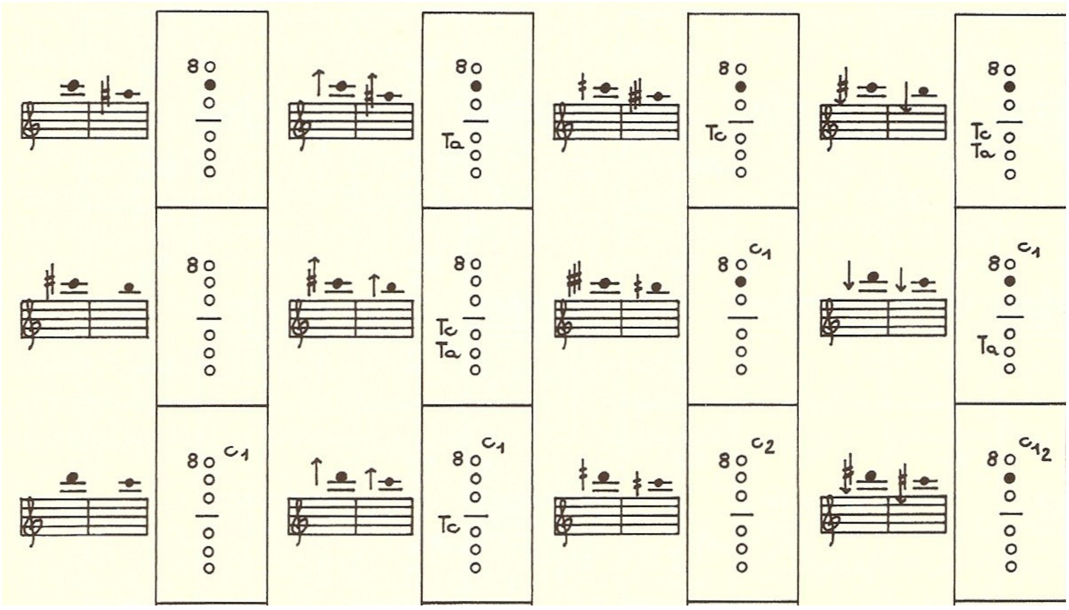
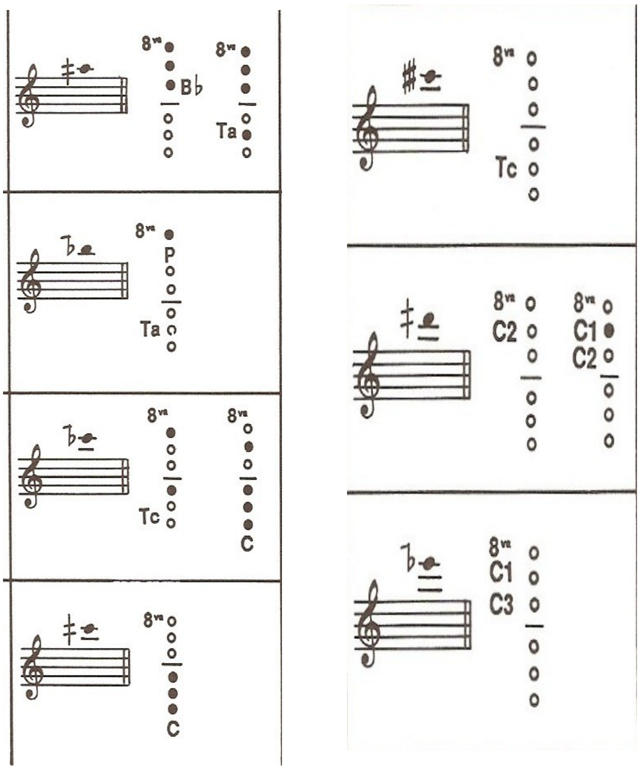


Fig.4.6.3 Fingering suggestions for microtones between the notes A5 and D5 quartertone sharp taken from Londeix (1989)



There are inevitable cross-overs in fingering suggestions between the two texts as displayed above. These cross-overs usually occur where the key work on the instrument results in only one microtonal fingering being available. For example the fingering for Weiss & Netti's A5 three quartertones sharp is the same as Londeix's B5 quartertone flat, even though they are notated enharmonically; therefore, the only choice available to the performer for sharpening the note Bb5 is to use the *bis* fingering (first finger plus the *bis* key) and to add the Bb trill key to raise the pitch. It is the discrepancy between these two resources that offer the performer choice as to how much to close the sonic gap between microtones, and therefore create the 'compression' the composer wishes to convey.

The following table shows those fingerings that are conflicting in both Weiss & Netti and Londeix's book.

Table 28: Fingering suggestions from Weiss & Netti (2010) and Londeix (1989)

Pitch	A5 quartertone sharp	B5 quartertone sharp	C5 quartertone sharp	C5 three quartertones sharp	D5 quartertone sharp
Weiss and Netti	814Hz	912Hz	990Hz	1042Hz	1094Hz
Londeix	798Hz	927Hz 930Hz	952Hz	1013Hz	1094Hz 1080Hz

In order to compress the sound into as small a sonic space as possible the fingerings that are higher in frequency are preferable for use in this piece. This is because each microtone is notated as a qartertone or three quartertone sharp, because the lines of the work are consistently ascending, a higher frequency will always be closer to the next note in the sequence. The only exception to this rule would be the last note of D5 quartertone sharp for which the lower frequency is preferable so that this pitch is sonically close to the overall collection of notes. My fingering choices for the piece are therefore as follows:

Table 29: Fingering choices for from Weiss & Netti (2010) and Londeix (1989) for use in Ben Isaacs I Never Look Like Myself (2009)

Pitch	A5 quartertone sharp	B5 quartertone sharp	C5 quartertone sharp	C5 three quartertones sharp	D5 quartertone sharp
Fingering Suggestion	Weiss & Netti	Londeix	Weiss & Netti	Weiss & Netti	Londieix

Embouchure Techniques

As well as the microtonal content the main characteristic of this work is the minimal sound that is produced during its performance. In his book *Hello! Mr. Sax* (1989) Londeix states that 'The saxophone can produce all dynamic levels from an intense *forte* down to a *piano* – placed at the limit of silence -. It is a question of the ability of the musician or, more precisely that of his technical ability.' (Londeix, 1989 p.84). Londeix makes this point to contradict the misconception that the saxophone is a 'loud instrument' and is incapable of being played quietly, and he goes on to explain that 'The *p* of the [accompanying voice], consciously played with a less brilliant tone color, is an easily recognizable technique for saxophones; it is made by using the technique referred to in jazz as '"subtone"' (Londeix, 1989 p.84). As Londeix suggests it is the subtone technique that needs to be employed to play 'at the limit of silence' and it is this technique which will be employed during *I Never Look Like Myself* (2009) in order to achieve *niente* playing (a contradiction in terms) growing in volume to 'barely there'.

Normally subtone is achieved by exposing more of the lower lip to the reed so as to restrict the vibration and to 'make heard the fundamental of a sound without its natural overtones or harmonics' (Londeix, 1989 p.84). This gives an airy sound as only a portion of the air is used to vibrate the reed, however, on the soprano saxophone it is possible in this range to omit this air sound using subtle changes of lip pressure as the dynamic rises. With a combination of increasing air pressure from the diaphragm, and gradually rolling the lower lip forward into the normal playing position, the saxophonist can achieve a crescendo from air only to very gentle sound and then, reversing the gesture, achieves the decrescendo. As has been stated previously a feature of this piece is non-specific timing of these *crescendo/diminuendo* and the note being sounded at the peak of the hairpin that is a feature of the work. The speed of the semiquaver and demi-semiquaver gestures that make up the work ensures that this non-specific approach is maintained as the saxophonist will sound only one or two pitches at the height of each hairpin, but the specific pitches sounded should differ from performance to performance.

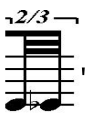
Section 7

Ray Evanoff *Diagramming a Vivisection of Yours and Mine (Ineffectual Tracings of Antiquated Sounds): A Floregium* (2010)

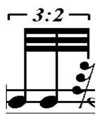
The music of Ray Evanoff is created from seemingly disparate gestures brought together and overlaid on top of one another which results in a multi-layered complexity affecting the notational values of the gestures giving multiple senses of pulse sounding simultaneously within a solo work. In the performance directions for the piece the composer states:

> Rhythm is generally spaced proportionately, with exceptions being made in the case of extremely tight durations caused by overlaying triplet and standard values, as well as in the case of a few extremely lengthy durations. Where possible, rhythmic values have been beamed to show 8th-note groupings - this has been done only for reasons of performance practicality, meaning that the presence, absence, or displacement of an 8th-note pulse should not be regarded as materially significant.

The idea that an overall pulse is not 'materially significant' is one aspect of the composition's character, and is further complicated by the device of using '2/3' time over specific notes or rests whereby in each instance:



' lasts for the equivalent of rest which would align it



but lacks the accompanying with a standard 16th-note value'

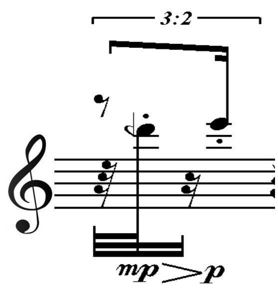
The device of composing a piece which includes layered material so as to break away from a sense of an empirical pulse is further enhanced by the use of microtones throughout the work.

These microtones serve to compress and augment the pitched material in the work, often with identifiable patterns occurring within each 'layer' but sounded at the same time. There are two types of microtone used throughout this work: microtones that are derived from a vented or forked fingering; and those that are derived from a partial of a multiphonic. Multiphonics are also used throughout the work and these are split into the three playing categories of type B multiphonics (sound with strong oscillation); type C multiphonics (wide dyad, stable); and type E multiphonics (narrow dyad). These multiphonic types are used within one layer of the composition and are even interrupted by the second layer, again enhancing the compositional technique on display within the work. This constant tension between the two layers of compositional material are enhanced through the use of these techniques, and my choice of production techniques and fingerings are based upon the need to emphasise this feature. As the composer states 'The intention... is to indicate a collision between materials/forces, and it is the expression of this collision that is most important'.

Microtones

Throughout the composition, Evanoff uses phrases that purposefully place microtonal alternative of a pitch alongside the regularly tempered version of the same pitch, this device serves to compress the pitched material within a layer which is often interrupted by the second layer of the composition. This is exemplified by the two note phrase in figure 4.7.1, acting as a motif throughout the work, which shows the device of two layers converging upon the same gesture as indicated by the use two different beams (track 100).

Fig.4.7.1 Ray Evanoff *Diagramming a Vivisection of Yours and Mine (Ineffectual Tracings of Antiquated Sounds): A Floregium* (2010) mvmt 1 page 1 line 4



In order to emphasise the feature of one microtonal layer being interrupted by a non microtonal layer the D6 quartertone flat will benefit from being accurately located half-way between C6 and D6 as this will emphasise the microtonal interval between the two notes. Referring to Weiss & Netti (2010) and Londeix (1989) gives the saxophonist fingering alternatives for this note, and in this instance the target frequency that will be required for the microtone is (concert C6 (1046Hz) – concert B5 (987Hz) = 59Hz) 1016Hz as this is B5 (987Hz) plus half of the difference between the two notes surrounding the microtone (59Hz ÷ 2 = 29.5HZ). Of the two fingering options available from the main resources it is

Londeix's suggestion which comes closest at 1014Hz with Weiss and Netti's suggestion being much sharper at 1029Hz, making it very close to concert C6 which sounds at 1046Hz. For a specific interval such as the one shown in figure 4.7.1 it is important to maintain the accuracy of the quartertone as it is this augmentation of an interval which creates the sense of interruption (this being the main feature of the work).

The second use of microtones within the work is the placing of it alongside the normal tempered pitch which has the effect of accentuating the difference in tuning between the two pitches. Figure 4.7.2 is an example of this type of gesture includes the written notes A5

Fig.4.7.2 Ray Evanoff *Diagramming a Vivisection of Yours and Mine (Ineffectual Tracings of Antiquated Sounds): A Floregium* (2010) mvmt 1 page 1 line 2

quartertone flat immediately followed by A5. Because this gesture is fast (occurring in the time of one quaver of the overall pulse) the fingering needs to be easily executable, which is not problematic for this pitch as the general consensus for flattening the note A is to create a one or two fingered fork by putting the right hand down, and this can be seen in figure 4.7.3 which shows both Weiss & Netti's and Londeix's suggestions.

Fig.4.7.3 Fingering suggestion for the note A5 quartertone flat as taken from Weiss & Netti (2010, left) and Londeix (1989, right)

This is the case for each instance when this gesture occurs, (figure 4.7.4). Every time this quick phrase is featured the addition of either a vent fingering (trill key) or a forked fingering works at the speed necessary and the texts agree on these fingerings (figure 4.7.5, track 101).

Fig.4.7.4 Examples of consecutive microtones with tempered notes taken from Ray Evanoff's *Diagramming a Vivisection of Yours and Mine (Ineffectual Tracings of Antiquated Sounds): A Floregium* (2010)

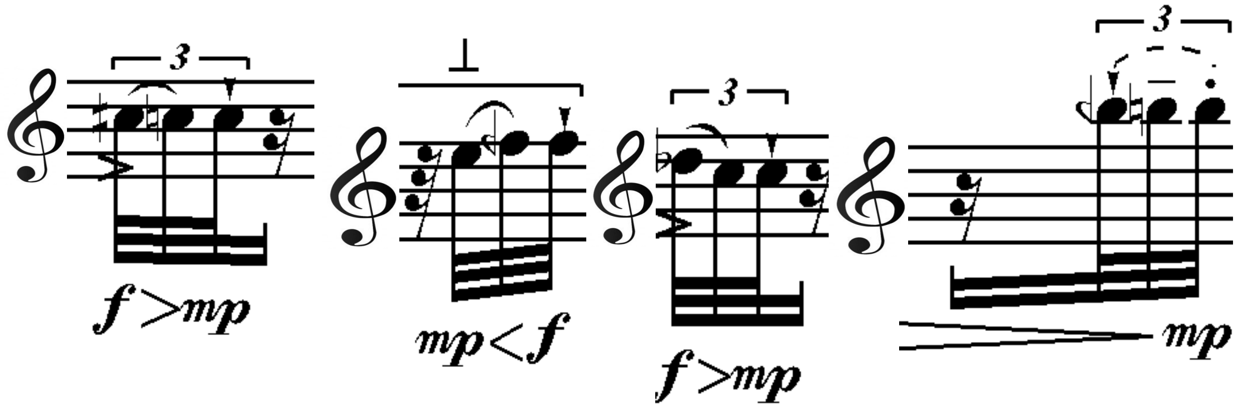
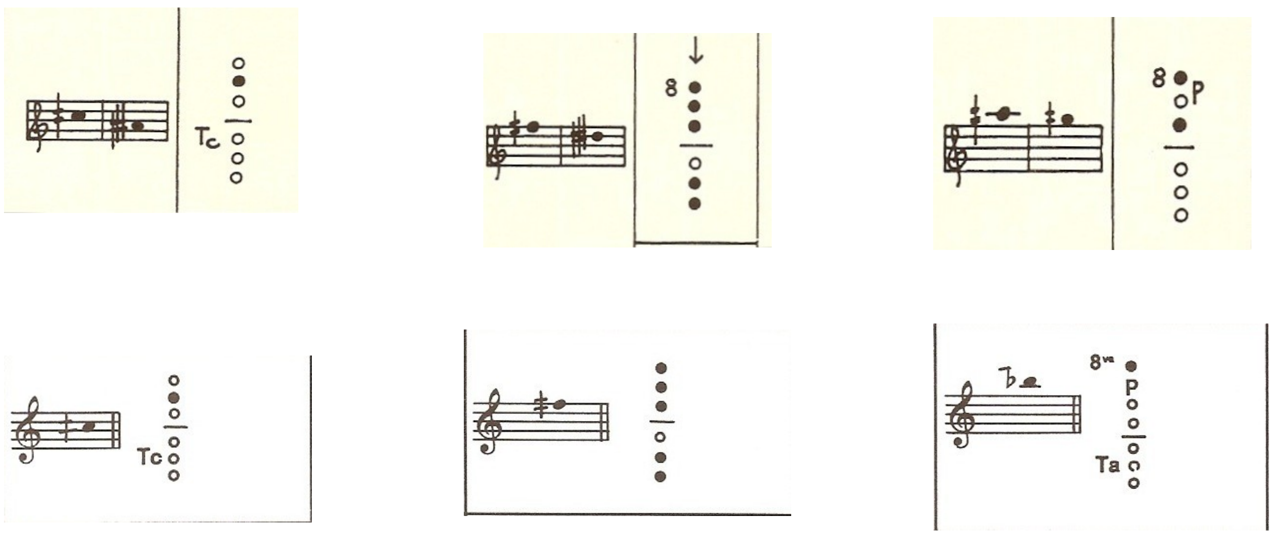


Fig.4.7.5 Fingering suggestion for the notes C5 quartertone sharp,F5 quartertone sharp and B5 quartertone flat as taken from Weiss & Netti (2010, top) and Londeix (1989, bottom) n.b Londeix's fingering for B5 quartertone flat uses the 'Ta' trill key to produce the fork instead of the third finger; the result is, however, the same.



The third incarnation of microtones in Evanoff's piece feature microtones that are actually a partial of a multiphonic. In order to maintain the sound of these microtones, the partial can be played with the other partial suppressed by the tongue thus giving the phrase a consistent sound. Figure 4.7.6 shows an instance from the beginning of the work where the lowest fundamental of the multiphonic is sounded by adopting the subtone embouchure thus stopping the upper partials from sounding. The example in figure 4.7.6 is straightforward in its production technique (track 102); however, other instances of the usage of these multiphonics offers the performer a choice as to the production of pitches in the work.

Fig.4.7.6 Ray Evanoff *Diagramming a Vivisection of Yours and Mine (Ineffectual Tracings of Antiquated Sounds): A Floregium* (2010) mvmt 1 page 1 line 1

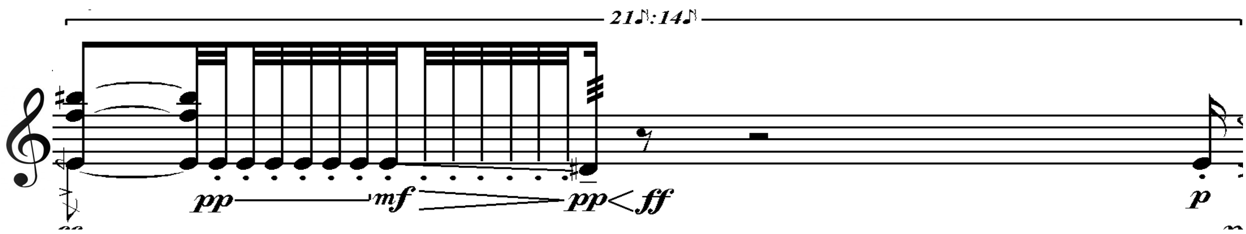
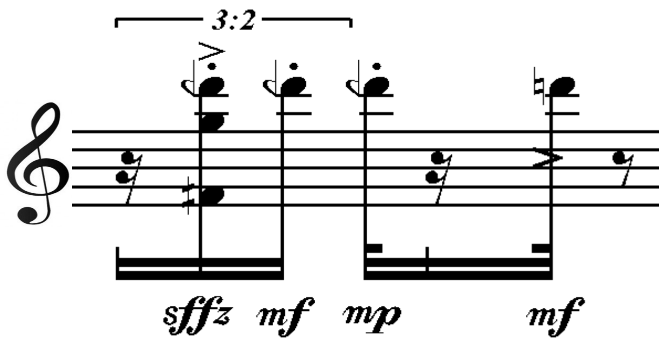


Figure 4.7.7 shows an instance from second movement where a multiphonic is sounded followed by the top note of the multiphonic on its own. In this passage the performer has the choice of sounding the individual pitch (D6 quartertone flat in the case of figure 4.7.7) as a microtonal fingering or as the top partial of the multiphonic, thus

Fig.4.7.7 Ray Evanoff *Diagramming a Vivisection of Yours and Mine (Ineffectual Tracings of Antiquated Sounds): A Floregium* (2010) mvmt 2 page 5 line 3



maintaining the multiphonic fingering (track 103). When the two versions of the D6 quartertone flat are measured on the oscilloscope, the fundamental fingering sounds at 1014Hz yet the top partial of the multiphonic sounds at 1035Hz. As the top partial is sharper than the vented fingering, it should be used in order to maintain consistency within the phrase.

Multiphonics

The composer uses three different multiphonic types throughout the work, each of which serves a specific gestural purpose. Table 30 displays the multiphonics that are used in group order, as well as the dynamic range used for each group:

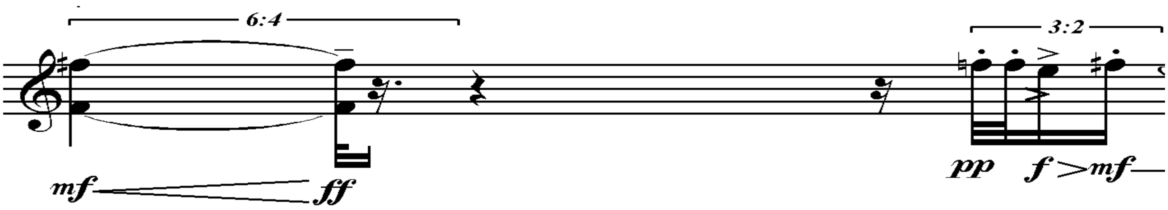
Table 30: List of multiphonics used in Ray Evanoff *Diagramming a Vivisection of Yours and Mine (Ineffectual Tracings of Antiquated Sounds): A Floregium* (2010)

Multiphonic type	B (Sound with strong oscillation)	C (Wide dyad, stable)	E (Narrow dyad)
Kientzy number	5	20	6
Kientzy number	11	26	40
Kientzy number	16		21
Kientzy number	17		55
Kientzy number	36		76
Kientzy number	46		
Dynamic	*pp - sfffz*	*mp - ff*	*pp - mf*

The most dynamically versatile group being the multiphonics that make up group B, with these multiphonics often being used for very loud accents, or to crescendo from *pianissimo* to a louder dynamic such as *forte* or *fortissimo* and louder. The production of this multiphonic group is malleable as the throat positions needed range from the 'hawed' position throughout the entire range to the 'hid' position allowing these multiphonics (as we have seen in the previous section) to be manipulated so that only single partials sound in certain phrases.

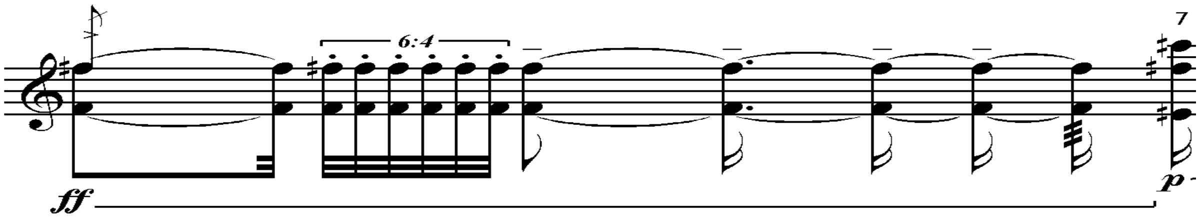
The two type C dyads used are based around de-tuned octaves and are used to highlight the microtonal shift from a pitch within the multiphonic to a fundamental pitch. Figure 4.7.8 shows a moment from movement 2 where the type C multiphonic, which has a top partial of

Fig.4.7.8 Ray Evanoff *Diagramming a Vivisection of Yours and Mine (Ineffectual Tracings of Antiquated Sounds): A Floregium* (2010) mvmt 2 page 4 line 1



F5 quartertone sharp, is immediately followed by F5. This also occurs between multiphonics as shown in figure 4.7.9 where the same multiphonic with F5 quartertone sharp as its highest partial is immediately followed by a second type C multiphonic with a middle partial being F5 quartertone sharp.

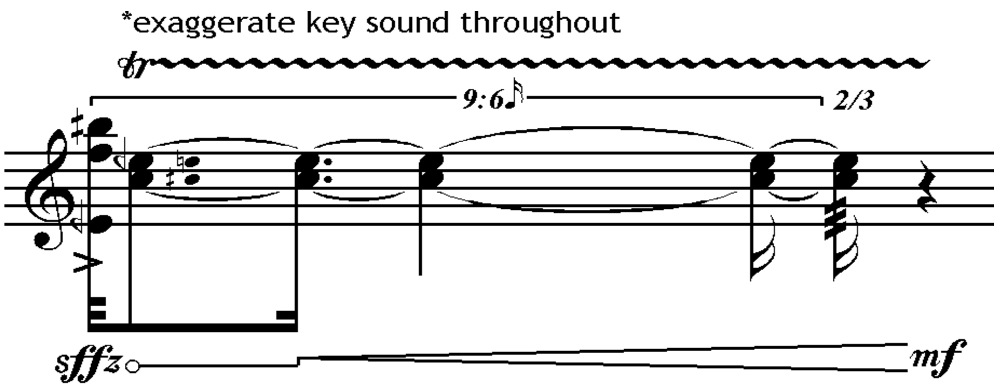
Fig.4.7.9 Ray Evanoff *Diagramming a Vivisection of Yours and Mine (Ineffectual Tracings of Antiquated Sounds): A Floregium* (2010) mvmt 2 page 4 line 3



At a glance the multiphonic at the end of figure 4.7.9 may appear to be a type B multiphonic as it uses similar intervals of type B multiphonics and an oscillation can be achieved; however, it is in the production of type B multiphonics that their identification is manifest. The tongue position for this multiphonic type is much more specific than type B multiphonics because, to achieve an oscillation including both pitches, the tongue needs to pitch the highest partial whilst dropping the lower jaw very slightly. This allows the reed to vibrate more freely, thus sounding the multiphonic. As this multiphonic type is not as malleable as type B multiphonics it is not therefore possible to emphasise the F5 quartertone sharp in the second multiphonic of figure 4.7.9 in order to match it to the same note in the previous multiphonic.

The last multiphonic type used is type E which results in narrow dyads, either de-tuned thirds or seconds. This multiphonic type also requires a specific pitching method which involves the 'who'd' tongue position, and due to the nature of these narrow intervals manipulation is not possible other than sounding individual partials (which is not asked for in the score). The composer has included trills on some dyads as shown in figure 4.7.10 which are possible due to the mechanical nature of adding a one finger fork into the fingering to slightly flatten the pitch; a technique which has previously been encountered in the case of microtonal fingerings.

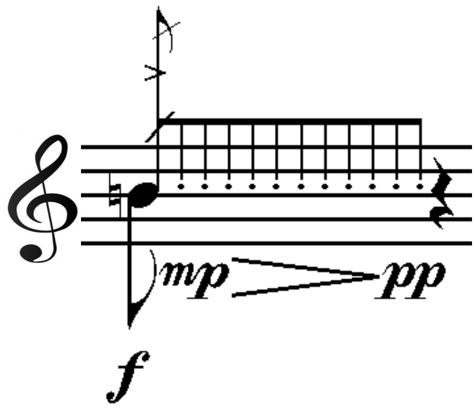
Fig.4.7.10 Ray Evanoff *Diagramming a Vivisection of Yours and Mine (Ineffectual Tracings of Antiquated Sounds): A Floregium* (2010) mvmt 2 page 5 line 2



Slap Tongue

The composer uses slap tongue in this composition as another interruption technique, often pairing the slap with type B multiphonic in order to deliver the maximum impact on the sound. As well as using the slap to accentuate a dynamic or timbral contrast, Evanoff uses the technique in order to explore different approaches to articulation; the antithesis of this technique being his direction on certain pitches not to use the tongue at all but to articulate from the diaphragm only. Figure 4.7.11 shows a feature of the composition where the slap is followed by multiple repetitions of the same pitch, which are achieved by using double tonguing with an un-specified number of repetitions. In these instances, and indeed throughout the piece, the slap tonguing technique used is the standard slap which Weiss & Netti describe as having 'a clear pitch and the typical noise component of the slap-tongue. It is produced with the normal embouchure, can be performed as a very short sound or as the attack of a sustained tone' (Weiss & Netti, 2010 pp.142-143). It is the latter of these two productions, which has a sustained tone, that is required for Evanoff's piece and the slap should be viewed as one of a number of articulation techniques used.

Fig.4.7.11 Ray Evanoff *Diagramming a Vivisection of Yours and Mine (Ineffectual Tracings of Antiquated Sounds): A Floregium* (2010) mvmt 2 page 5 line 1



Conclusion

Implications for Performance

When realising an extended technique, performers must choose an appropriate method of sound production based upon their understanding of the technique's significance within the work. These choices are based upon an analysis of the piece and an identification of the important relationships within the composition, which can be emphasised through the manipulation of the various extended techniques. In the introduction to this thesis the following quote from Lester (1995) was discussed in relation to performance:

> each nuance limits the piece by excluding other options for that element. In this sense, a performance is necessarily only a single option for that piece, delineating some aspects while excluding others
>
> (Lester, 1995, p.199)

Due to the nature of music performance, which only allows an audience to experience the art form in a single temporal space, a performer can only present one interpretative choice for a composition at any one time. This means that the choice of emphasis for each compositional 'element' when approaching extended techniques takes on a significance when portraying the important relationships to an audience.

Each composition has identifiable relationships between the use of extended and standard playing techniques, and these relationships can manifest themselves in a number of ways: pitch relationships within microtones; pitch relationships within multiphonics; beating patterns within multiphonics; beating patterns within singing and playing passages; rhythm and pitch elements whilst using slap tongue; and so on. These compositional elements are often related to, and perhaps even the reason for, the extended techniques the composer has chosen for that particular passage. In identifying the technique's role within the composition, the performer can then consider the nuances within the technique that can be expressed with the intention of emphasising the relationships that have been identified. With this approach the performer can decide on the aspects of the work they deem important and present them for performance. Although, due to the nature of live performance, the resulting sound may change through inaccuracy or accident, the performer's decision-making process about the piece has been completed and the performer's individual interpretation can be moulded in this way.

In order to successfully achieve the level of nuanced performance required when interpreting extended techniques, it is my argument that the performer needs to understand the acoustical behaviour of their instrument, and the sounds that it can produce. It is through an understanding of the saxophone's harmonic series, mechanical system, bore shape, and the importance of mouthpiece and reed system, as well as such acoustical phenomena as fork fingering, heterodyne components, and the tongue's role in creating Bernouilli's effect, that the performer can master the physiological challenges necessary to create the desired sounds. The performer can view each physical manipulation as a separate gesture within the linear progression of the piece. This approach to interpretation allows for the amount of muscle memory (the 'recall' that Rob Buckland refers to) needed to achieve the desired manipulation to be learned in a linear fashion, treating the techniques as 'events' which occur in a linear time frame, and thus manipulating a 'temporal realisation' within the linear field as explained by Clarke (1995, p.51). By approaching a work in this way a performer can achieve the amount of recall needed to perform the intricate level of detail associated with this style of performance.

New Compositions for the Saxophone

Sections 5, 6 and 7 of chapter 4 of this thesis describe this method of playing in relation to three compositions that were written for the author in close collaboration with the composer. These compositions offer the performer the opportunity to consider not only fingering patterns and exercises, but also the oral cavity manipulations needed to make some of the techniques work. This is especially true of Scott Mc Laughlin's *Neither Wholes nor Parts*

(2010) which is made up entirely of multiphonics which are manipulated in this way. There are works appearing in the saxophone's repertoire which require mastery of the 'internal elements' of tongue position and oral cavity manipulation. Established works of this type include *Asphyxia* (2000) by Aaron Cassidy, *Graffiti* (1993) by Roger Redgate and *Largo calligrafico / "patientiam"* (2012) by Evan Johnson, all of which require specific tongue and oral cavity manipulations to execute their extremely fast rhythms. Chris Redgate's article *Re-inventing the Oboe* (2007) outlines his personal approach to realising the scores of both Roger Redgate and Michael Finnissy by describing which tongue positions will allow him to execute the music, indicating that woodwind technique is advancing to meet the demands of the score. However, performers often find themselves wanting for teaching and learning materials which adequately explain how this way of playing can be achieved. As extended techniques are delicately integrated into these scores the manipulation of them becomes part of the overall instrumental technique needed to execute the music, again presenting an instrumental technique which is concerned with both internal and external 'elements'.

Implications for Saxophone Pedagogy

The performer needs to achieve a great deal of dexterity within the oral cavity whilst manipulating extended techniques in this way. This is an aspect of saxophone technique that is overlooked in the standard methods and tutor books as discussed in chapter 1, which rely heavily on external elements such as fingering charts and exercises, rather than internal elements such as tongue position and oral cavity shape. The first exercise in Trevor Wye's flute method *Practice Book for the Flute. Book I: Tone* (1999, p.4) has the student manipulating the harmonic series in the same way that the saxophonist is asked to in Rousseau's and Rascher's books as described in chapter 1, figure 1.8. The emphasis of the harmonic series as an element of basic technique seems appropriate for flute playing, however I would argue that it is just as important to basic saxophone technique as the tone can be much improved by adopting register-specific tongue positions (rather than air stream direction in the case of the flute). Bartolozzi reminds us that the woodwind instruments are 'the only ones which use a 'mixed' system of sound production (i.e. fundamental tones for the lower register and various natural harmonics for the upper registers)' (Bartolozzi, 1982 p.12). This observation highlights the importance of the harmonic series to all woodwind instruments and therefore the necessity to understand the manipulation of it. The recent tutor book *Playing the Saxophone* (2012) released by Rob Buckland begins to indicate the importance of vowel shapes on tone through the inclusion of his 'Vowel Superimposition Exercise' where the student is encouraged to form different vowel shapes when playing in the different registers of the saxophone. There are three vowels mentioned covering three registers: 'AAH' covering the notes from Bb3 to C#5, 'OOH' covering D5 to A5 and 'EEE' for notes higher than A5. This roughly corresponds with the mechanical working of the saxophone: 'AHH' being the fundamentals, 'OOH' being the notes played with the first octave pip and 'EEE' being those notes played with the second octave pip. This method introduces the idea of how vowels can aid tone production as the saxophonist is tuning their vocal tract and focussing the air in the correct way. The method does not mention which saxophone this exercise should be played on, and the idea that these vowel shapes will work on all of the saxophones is contradictory to Buckland's own assertion that tongue placement is specific to pitch (a G6 on the alto is the same tongue position as a C6 on the soprano) as quoted in chapter 3 of this thesis. In order to manipulate the saxophone with any level of detail, much more nuanced vowel shapes and tongue placements need to be considered in future exercises for students.

Teaching is often hindered in this respect by the lack of this awareness reflected in the syllabus of the music examination bodies, rendering the need to teach this level of detail unnecessary. I have already mentioned in chapter 1 that the examination bodies do not require two octave scales on the note F#, as not every saxophone has the necessary F#6 key. This key is not the only way to play F#6, however, and to learn the forked (or 'front') F#6 fingering the pupil would need to learn a specific tongue position very similar to playing in the altissimo range to sound the note. The presence of this note would encourage the use of the oral cavity shape and thus promote good technique as outlined in Rob Buckland's method through the use of vowel sounds. Repertoire pieces which use harmonics, such as the second movement of Phil Woods' sonata (1997), could also be considered to introduce young learners to these techniques and to prepare them for pieces which use extended techniques when they appear in the syllabus for the diploma examinations.

Developing a New Instrumental Technique – Understanding Internal Elements

The research that has been done into tongue position and oral cavity manipulation by acousticians such as Chen, Wolf et al has been successful in collecting data pertaining to the tongue and larynx placement for both the basic and extended ranges of the saxophone. These studies have not, however, considered how the tongue affects the tone of the instrument during normal playing (perhaps due to the subjective nature of tone production and preference), or how the tongue is able to sound individual partials in a multiphonic through the specific adjustment of it within the oral cavity. Much work has been done collecting data from videofluerography and laryngoscopy regarding the altissimo register, but no data has been collected in regards to multiphonics. In my opinion this opportunity to understand the full significance of Bernouilli's principle has been missed, and more data needs to be collected to explain exactly what happens when sounding multiphonics in order to help the performer achieve the sound which is desired.

To disseminate this data, I do not believe a textbook-approach would be sufficient as that would demonstrate the same problems of concentrating on the tables and charts associated with 'external elements' as described above in relation to Buckland's method. An interactive tool would be more appropriate to show the performer how the air stream changes as it is compressed by the tongue, and which vowel sounds will help the performer achieve this. Ellen Fallowfield's recent website www.cellomap.com goes some way to helping performers understand the extended techniques possible on the cello through use of tutorial videos and diagrams. Similarly, www.clarinet-multiphonics.org uses flash animations to indicate what happens within the tube of the clarinet as dictated by the fingerings to create multiphonics (a mixture of both internal and external elements, although this website makes no mention of how the player places the tongue). I believe a mixture of these two devices of tutorial videos and flash animations would create a valuable resource for saxophonists trying to achieve extended techniques on their instrument by demonstrating both the internal and external elements through interactive animations and tools.

Appendices

Appendix 1

Track list for the accompanying CD of audio examples.

Equipment used:

Soprano saxophone – Selmer Mark VII prototype. Selmer C** mouthpiece.

Alto saxophone – Selmer balanced action. Vandoren AL3 mouthpiece and Freddie Gregory F6 mouthpiece.

Tenor saxophone – Yamaha YTS27. Selmer D mouthpiece and Berg Larson 110 mouthpiece.

Flute – Emerson

Clarinet – Buffet R13, Yamaha YCL5 mouthpiece.

All tracks were recorded using a stereo pair of DPA 4006 Omni microphones, with the exception of track 30 which was recorded on a Shure SM57.

Track Number	Description	Chapter	Page	Instrument
1	Kientzy multiphonic number 1 for alto as taken from *Les Sons Multiples Aux Saxophones* (2003)	Introduction	24	Alto saxophone
2	Fig.2 Kientzy multiphonic number 115 for alto as taken from *Les Sons Multiples Aux Saxophones* (2003)	Introduction	26	Alto saxophone
3	Arno Bornkamp - Denisov *Sonata* Mvmt II b.1	Introduction	27	-
4	John Harle - Denisov *Sonata* Mvmt II b.1	Introduction	28	-
5	Claude Delangle - Denisov *Sonata* Mvmt II b.1	Introduction	28	-
6	Fig.4 Takashi Yoshimatsu *Fuzzy Bird Sonata* (1995) p.1 line 4	1	37	Alto saxophone
7	Fig.5 Nicolaus A. Huber *Aus Schmerz und Trauer* (1982) p.11 b.5	1	37	Alto saxophone
8	Fig.6 Fuminori Tanada *Mysterious Morning III* (1996) p.7 line 7	1	37	Soprano saxophone
9	Fig.7 Mike Vaughan *Ensphered* (1990) bb.9-10	1	38	Soprano saxophone
10	Fig.9 Yoshihisa Taïra *Pénombres VI* (1996) p.1 line 1	1	39	Alto saxophone
11	Fig.14 Fuminori Tanada *Mysterious Morning III* (1996) p.3 line 1	1	42	Soprano saxophone

12	Fig.15 Fuminori Tanada *Mysterious Morning III* (1996) p.10 line 4	1	42	Soprano saxophone
13	Fig.16 Betsy Jolas *Épisode Quatrième* (1983) p.4 line 5	1	42	Tenor saxophone
14	Yoshihisa Taïra *Pénombres VI* (1996) p.8 line 3	1	43	Alto saxophone
15	Type Ba multiphonic	1	45	Alto saxophone
16	Type CE multiphonic	1	45	Alto saxophone
17	Type Ce multiphonic	1	45	Alto saxophone
18	Type Cb multiphonic	1	45	Alto saxophone
19	Type C multiphonic	1	46	Alto saxophone
20	TypeD/B multiphonic	1	46	Alto saxophone
21	Type Da multiphonic	1	46	Alto saxophone
22	Type E multiphonic	1	46	Alto saxophone
23	Type Eb multiphonic	1	46	Alto saxophone
24	Fuminori Tanada *Mysterious Morning III* (1996) p.6 line 5	1	48	Soprano saxophone
25	Luciano Berio *Sequenza VIIb* (2003) line 13 taken from Delangle (1993)	1	48	Soprano saxophone
26	*Harmonique* taken from Coltrane jazz (1961) by John Coltrane	1	49	-
27	Pedro Itturalde *Pequena Czarda* (1997) p.3 lines 7 and 8	1	54	Alto saxophone
28	Secco slap, normal slap and embouchure slap as identified by Weiss & Netti (2010)	1	59	Alto saxophone
29	Fundamental and three partials on the flute (tube entirely closed)	2	65	Flute
30	Fundamental and three partials on the clarinet (tube entirely closed)	2	68	Clarinet
31	Fundamental and three partials on the	2	70	Soprano

	soprano saxophone (tube entirely closed)			saxophone
32	A = 440 on vandoren AL3 mouthpiece	2	77	Alto saxophone
33	A = 440 Freddie Gregory F6 mouthpiece	2	77	Alto saxophone
34	A = 440 on Selmer D mouthpiece	2	78	Tenor saxophone
35	A = 440 Berg Larson 110 mouthpiece	2	78	Tenor saxophone
36	Kientzy multiphonic number 55	2	82	Soprano saxophone
37	Kientzy multiphonic number 46	2	84	Soprano saxophone
38	G – G quartertone sharp-G# using the mechanical alteration	2	91	Alto saxophone
39	Denisov's Sonata for Alto Saxophone and Piano (1973), movement II, line using the 'lâcher les lévres' technique	2	92	Alto saxophone
40	Denisov's Sonata for Alto Saxophone and Piano (1973), movement II, line using the mechanical alteration technique	2	92	Alto saxophone
41	The four multiphonics used in Scavone et al's experiment to measure sound pressure levels recorded on the Vandoren AL3 mouthpiece	2	96	Alto saxophone
42	The four multiphonics used in Scavone et al's experiment to measure sound pressure levels recorded on the Freddie Gregory F6 mouthpiece	2	96	Alto saxophone
43	The resulting sounds from the diagram of the harmonic series played on the soprano saxophone and the corresponding tongue positions	2	110	Alto saxophone
44	Yoshimatsu *Fuzzy Bird Sonata* (1991) figure B (Nobuya Sugawa)	3	115	-
45	Yoshimatsu *Fuzzy Bird Sonata* (1991) figure B (Rob Buckland)	3	115	-
46	Yoshimatsu *Fuzzy Bird Sonata* (1991) figure B (Sarah Markham)	3	115	-
47	Yoshimatsu *Fuzzy Bird Sonata* (1991) figure J (Nobuya Sugawa)	3	116	-
48	Yoshimatsu *Fuzzy Bird Sonata* (1991) figure J (Rob Buckland)	3	116	-

49	Yoshimatsu *Fuzzy Bird Sonata* (1991) figure J (Sarah Markham)	3	116	-
50	Kientzy multiphonic number 36 upper partials suppressed	3	117	Alto saxophone
51	Kientzy multiphonic number 13 upper partials suppressed	3	117	Alto saxophone
52	Luciano Berio *Sequenza Ixb* (1980) figure J (Claude Delangle)	3	118	-
53	Luciano Berio *Sequenza Ixb* (1980) figure J (Wallace Halliday)	3	118	-
54	Kientzy multiphonic number 20	3	118	Alto saxophone
55	Luciano Berio *Sequenza VIIb* (2003) line 13 (Claude Delangle)	3	119	-
56	Luciano Berio *Sequenza VIIb* (2003) line 13 (Wallace Halliday)	3	119	-
57	Betsy Jolas *Épisode Quatrième* (1983) page 4 line 5 (Claude Delangle)	3	120	-
58	Betsy Jolas *Épisode Quatrième* (1983) page 4 line 5 (Daniel Kientzy)	3	121	-
59	Fuminori Tanada *Mysterious Morning III* (1996) page 6 lines 6 b.3	4	135	Soprano saxophone
60	Microtonal interval from Fuminori Tanada *Mysterious Morning III* (1996) page 1 line 1 - Tanada's fingerings	4	138	Soprano saxophone
61	Microtonal interval from Fuminori Tanada *Mysterious Morning III* (1996) page 1 line 1 - Weiss & Netti's fingerings	4	138	Soprano saxophone
62	Fuminori Tanada *Mysterious Morning III* (1996) page 3 line 1 vocal part sharp	4	146	Soprano saxophone
63	Fig.10 Fuminori Tanada *Mysterious Morning III* (1996) page 3 line 1 – vocal part flat	4	146	Soprano saxophone
64	Fuminori Tanada *Mysterious Morning III* (1996) page 8 line 2 – vocal part sharp	4	147	Soprano saxophone
65	Fuminori Tanada *Mysterious Morning III* (1996) page 8 line 2 – vocal part flat	4	147	Soprano saxophone
66	Kientzy multiphonic number 20	4	148	Soprano saxophone
67	Weiss & Netti multiphonic number 8	4	149	Soprano saxophone
68	Kientzy multiphonic number 1 &	4	149	Soprano

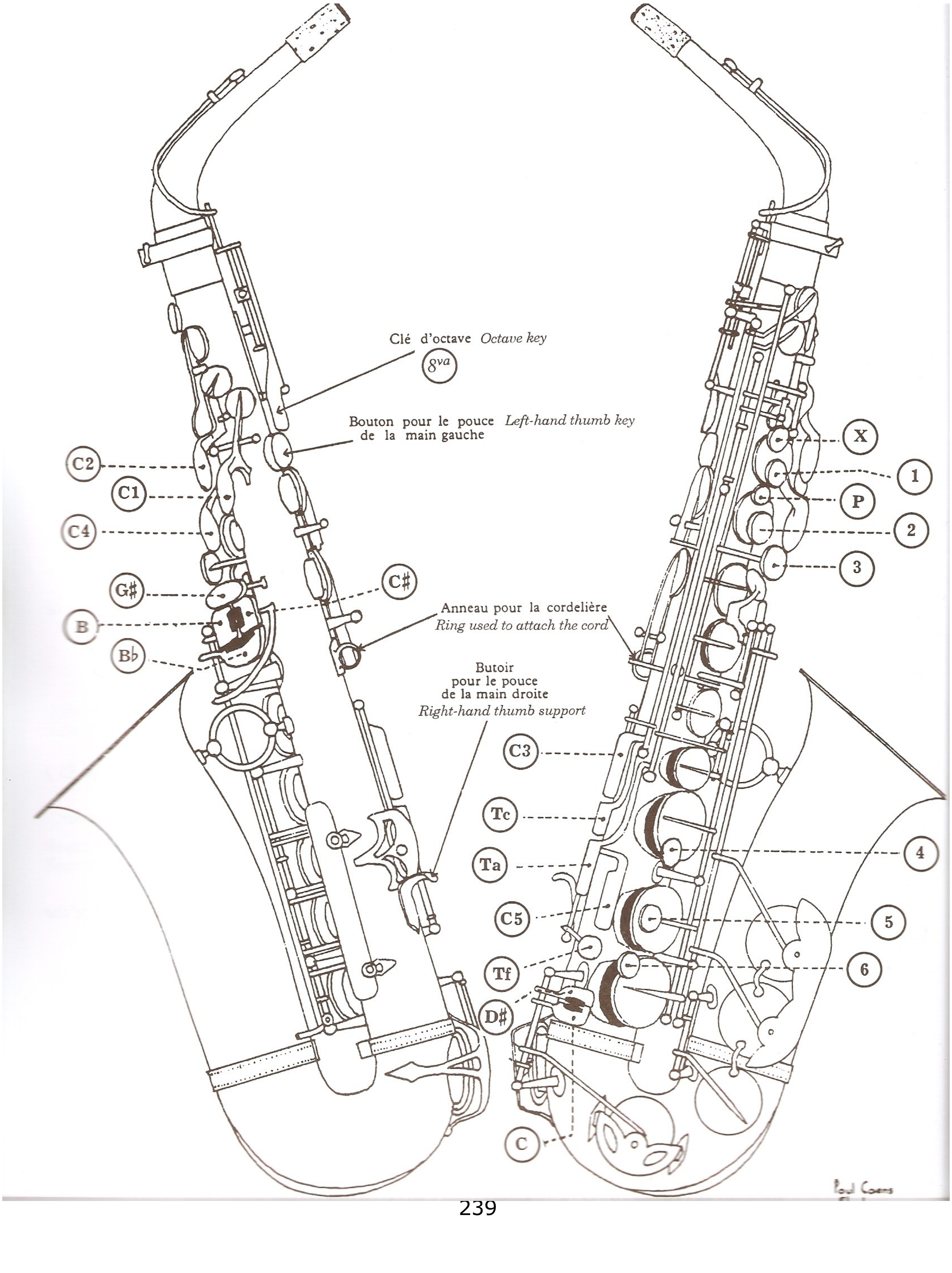
	Kientzy multiphonic number 85			saxophone
69	Nicolaus A. Huber *Aus Schmerz und Trauer* (1982) page 7 line 1	4	155	Alto saxophone
70	Nicolaus A. Huber *Aus Schmerz und Trauer* (1982) page 10 lines 1-2	4	156	Alto saxophone
71	Fig.4 triad multipshonics in order of appearance in *Aus Schmerz und Trauer* (1982)	4	158	Alto saxophone
72	Nicolaus A. Huber *Aus Schmerz und Trauer* (1982) page 5 line 3	4	162	Alto saxophone
73	'Lip glissando' played on the Vandoren AL3 mouthpiece	4	163	Alto saxophone
74	'Lip glissando' played on the Freddie Gregory F6 mouthpiece	4	163	Alto saxophone
75	Nicolaus A. Huber *Aus Schmerz und Trauer* page 9 lines 6 and 7	4	165	Alto saxophone
76	Betsy Jolas *Épisode Quatrième* (1983) page 3 line 6	4	167	Tenor saxophone
77	Betsy Jolas *Épisode Quatrième* (1983) page 5 line 2	4	168	Tenor saxophone
78	Betsy Jolas *Épisode Quatrième* (1983) page 5 line 2	4	168	Tenor saxophone
79	Betsy Jolas *Épisode Quatrième* (1983) page 6 line 6	4	168	Tenor saxophone
80	Betsy Jolas *Épisode Quatrième* (1983) page 6 line 5	4	172	Tenor saxophone
81	D#5 Bisbigliando	4	177	Tenor saxophone
82	G5 Bisbigliando	4	178	Tenor saxophone
83	Betsy Jolas *Épisode Quatrième* (1983) page 3 line 2	4	178	Tenor saxophone
84	Betsy Jolas *Épisode Quatrième* (1983) page 5 line 6	4	179	Tenor saxophone
85	Betsy Jolas *Épisode Quatrième* (1983) page 5 line 4	4	180	Tenor saxophone
86	Betsy Jolas *Épisode Quatrième* (1983) page 3 line 2	4	180	Tenor saxophone
87	Multiphonic used in Ichirô Nodaïra	4	186	Alto

	Arabesque III (1983) bb.1-3			saxophone
88	Ichirô Nodaïra *Arabesque III* (1983) bb.116 – 121 (Claude Delangle)	4	188	Alto saxophone
89	Ichirô Nodaïra *Arabesque III* (1983) b.120 (Claude Delangle)	4	189	-
90	E5 bisbigliando – Nodaira fingering	4	191	Alto saxophone
91	E5 bisbigliando – Weiss & Netti fingering	4	191	Alto saxophone
92	E5 bisbigliando – Londeix fingering	4	191	Alto saxophone
93	E5 bisbigliando – shared fingering	4	193	Alto saxophone
94	Ichirô Nodaïra *Arabesque III* (1983) b.153	4	196	Alto saxophone
95	Ichirô Nodaïra *Arabesque III* (1983) piano score b.82	4	199	Alto saxophone
96	Scott Mc Laughlin *Neither Wholes nor Parts* (2010) page 1 line 1	4	205	Alto saxophone
97	Scott Mc Laughlin *Neither Wholes nor Parts* (2010) page 1 line 2	4	206	Alto saxophone
98	Scott Mc Laughlin *Neither Wholes nor Parts* (2010) page 2 line 1	4	210	Alto saxophone
99	Ben Isaacs *I Never Look Like Myself* (2009) movement I bb.2-3	4	212	Soprano saxophone
100	Ray Evanoff *Diagramming a Vivisection of Yours and Mine (Ineffectual Tracings of Antiquated Sounds): A Floregium* (2010) mvmt 1 page 1 line 4	4	219	Soprano saxophone
101	Examples of consecutive microtones with tempered notes taken from Ray Evanoff's *Diagramming a Vivisection of Yours and Mine (Ineffectual Tracings of Antiquated Sounds): A Floregium* (2010)	4	221	Soprano saxophone
102	Ray Evanoff *Diagramming a Vivisection of Yours and Mine (Ineffectual Tracings of Antiquated Sounds): A Floregium* (2010) mvmt 1 page 1 line 1	4	222	Soprano saxophone
103	Ray Evanoff *Diagramming a Vivisection of Yours and Mine (Ineffectual Tracings of Antiquated Sounds): A Floregium*	4	222	Soprano saxophone

	(2010) mvmt 2 page 5 line 3			

Appendix 2

Diagram of the saxophone's mechanical system with names of keys as taken from Londeix's Hello! Mr. Sax (1989)



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