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**Spectral Immersions:  
A Comprehensive Guide To The Theory  
And Practice Of Bass Clarinet**

**Multiphonics**

**by Sarah Watts**

**PhD**

**March 2015**

**Keele University**

**Spectral Immersions is a multi-component research project.**

**This thesis has the following integrated aspects and media:**

**i/ Thesis and SW charts**

**ii/ Scores of new compositions**

**iii/ Data CD containing recordings from the SW charts and graphic finger notations**

**iv/ Audio CD with recordings of pieces written using the results of this research**

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Degree for which thesis being submitted PhD

Title of thesis Spectral immersions: a comprehensive guide to the theory and practice of  
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## ABSTRACT

*Spectral Immersions: A Comprehensive Guide To The Theory And Practice Of Bass Clarinet Multiphonics* is a multi-component thesis that looks into the entire area of multiphonic analysis and composition for the bass clarinet. A literary section of the thesis looks at past publications and the problems associated with using this contemporary technique, in terms of both compositional and performance issues. A theoretical analysis of Type One multiphonics gives an insight into how multiphonics on the bass clarinet work in a more scientific way and their close relationship with the harmonic series. A complete analysis of Type Two multiphonics using past charts and new-found fingerings results in the creation of the new SW multiphonic charts for the bass clarinet. The new SW charts are fully tested by correcting problems in past compositions by means of several student compositional projects at various UK universities. Finally, a new set of études and pieces have been commissioned by composers from the UK and abroad. The results and successes of the pieces and new SW charts are analysed and can be listened to via accompanying audio and data CDs.

The results of this thesis provide both performers and composers with an accurate, exhaustive and up-to-date usable publication. Not only does this thesis provide a new set of multiphonic charts, but the addition of compositional examples using multiphonics provides both practice and recital material for performers and useful compositional technique hints and advice for composers wishing to use this resource in the future.

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A big thank you to my friend and colleague in the Cuillin Sound Trio, Laurence Perkins, who has patiently recorded every multiphonic and the majority of new works composed for this project.

# Chapter 1

## Introduction

**“I think our task is to convince the composers that it [multiphonics] is a very risky business, and it is a very insecure business because, even when I change my reeds or I play the next day, they [the multiphonics] are changing<sup>1</sup>.”**

**Harry Sparnaay on multiphonics. Barcelona, May 2011**

Multiphonics have been an important extended contemporary technique that feature and highlight the soundworld and spectral harmonic frequencies of the bass clarinet. This is a technique that has been used extensively by composers writing not only for bass clarinet but for all woodwind instruments. A multiphonic is a technique that results in the creation of multiple pitches by using standard fingerings and manipulating the embouchure (altering the placing of the mouth position on the reed) whilst blowing air through the instrument in such a way that the sound splits into several prominent frequencies, or by using special fingerings that push the air through the instrument in a way that causes a disruption to the flow of the sound waves, resulting in a note splitting into multiple frequencies. To date, multiphonics for the bass clarinet is a complicated and controversial contemporary technique. They are often used as an effect that has limited success either due to inaccurately notated charts or to composers being ill-advised as to the limitations and restrictions that the bass clarinet can have on their execution and sounding. Since it is an harmonic (and inharmonic) compositional tool, composers have become wary of integrating multiphonics into the harmonic musical language of their music because they have lost confidence in the written and actual sounding results of existing charts. There are two types of multiphonics. Type One multiphonics are based on standard low note

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<sup>1</sup> Harry Sparnaay, Interview with Sarah Watts, Barcelona, 28 May 2011

fingerings and are produced by a player manipulating the embouchure in such a way that the frequencies of the harmonic series increase in audibility producing a strong set of multiple sounds. Type Two multiphonics are created by the player using special fingerings that are not the standard fingerings used when producing a single tone.

*Spectral Immersions* is groundbreaking, multi-component, comprehensive research into the area of bass clarinet multiphonics. This thesis addresses all of the past problems that have arisen with multiphonic usage in composition and, by means of a complete investigation and reanalysis, has taken a step towards correcting these problems and thus encouraged composers to regain lost confidence in this technique.

This is a project that looks at and reanalyses past charts<sup>2</sup> and their problems, analyses previously uncharted fingering combinations using up-to-date technology<sup>3</sup> and commissions and records new works. The intention of this project is to have a final outcome which will mean that composers can successfully explore the use of multiphonics in a variety of different ways in their music and also that both composers and performers will have an accurate publication to refer to and use in the future.

The components of this project are:

**i/ A literature review and an insight into bass clarinet multiphonics and problems to date**

This introduction considers the nature of multiphonics, how they work and how they have been analysed and used prior to the start of this project. I spent time carrying out comprehensive research on the various problems that have arisen for both composers and

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<sup>2</sup> Previous attempts to notate multiphonics (see chapter two).

<sup>3</sup> The use of spectral analysis software – *Audiosculpt* (IRCAM, FRANCE).

performers in the past and how this has affected the success of previous compositions. In chapter two there is a review of the literature on past attempts at analysing multiphonic charts, previous methods and approaches used to notate multiphonics and the successes or problems these charts presented, and all of these problems have formed an important part of the inspiration for this research. This part of the research also involved interviewing key performers and composers who have had a major influence on the use and development of music involving the use of multiphonics in the past and obtaining feedback from performers and composers on how they would like to see multiphonics being notated and used effectively. All of the research and evidence and the questions asked have played an important part in the results of this research and in the creation of the new “SW multiphonic charts”<sup>4</sup> for bass clarinet.

## **ii/ New charts**

This research has resulted in a new and originally presented set of analyses and charts. Via the use of *Audiosculpt*, which is spectral analysis software from IRCAM (Institute for Music/Acoustic Research and Coordination), in France, and by considering the demands of composers and performers, an accurate set of multiphonic charts has been created, analysed and notated for the first time. In terms of multiphonics, the analysis involves using this spectral software to accurately highlight and thus notate frequencies (both harmonic and inharmonic) that appear for each individual fingering. These are described throughout the research as the “SW (Sarah Watts) charts”.

## **iii/ New études and other compositions**

During a period of three years, the SW charts were designed and numerous new works were composed. These include works written using test charts that were compiled during

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<sup>4</sup> For the complete set of SW charts see Appendix 1

the making of the charts and pieces written after the completion of the first full drafts of charts were completed. A period of student testing resulted in several compositions being written to see how effective the SW charts were going to be and to discover problems that could potentially arise from their presentation. Following the completion of the first official draft of the SW charts, established composers were then asked and commissioned to write short études using the SW charts. The intention is that these new compositions will provide composers with examples of the effective use of multiphonics, whilst also providing students and performers with material that will not only help them master the technique of multiphonics but will also provide them with short, unaccompanied recital works. Some composers were requested to write more substantial works using multiphonics, and also works that used other instruments or electroacoustic technologies, so a selection of works influenced by a variety of different genres that use the SW charts also feature in this research. Finally, from a performer's perspective, I could see other ways of using multiphonics that composers had not yet explored, so I have contributed compositionally to this research and written the first of what I intend to be a series of solo works that feature multiphonics.

#### **iv/ Recordings and graphics of the multiphonics**

The SW multiphonic charts have been recorded in full. An accompanying data CD provides composers with a valuable resource illustrating how each multiphonic sounds. Also included are JPEG files containing the fingering for each multiphonic so that composers can import each fingering straight into a score as a graphic file. As a result of this, performers who do not have personal access to the SW charts will have both the notation and the fingerings needed in the musical scores.

Each multiphonic has been recorded at a stable mid-dynamic range and then also at the full scope of the dynamic range. This ensures that composers know which multiphonics will work only at quiet and loud dynamics and which are more flexible.

#### **v/ Recordings of the pieces**

An audio CD accompanying this thesis showcases a large selection of the works written for this research. This CD can be used to aid performers who are learning the works and to inspire composers and give them ideas about how to use multiphonics successfully in the future.

#### **vi/ Justification and evaluation**

The results and successes of this research are included in the final chapters. The feedback that performers and composers have given is highlighted and is crucial to the future success and development of the project. Finally, by way of the analysis and creation of new multiphonic charts and the composition of new works, this project has opened up further research questions and areas for the continuation and further development of research, which are examined in the final chapter.

The final product of this research is the creation of the largest single collection of multiphonics analysed using electroacoustic technology in a newly presented and originally notated way. This is the result of looking at past charts and their problems and reacting to the feedback of both performers and composers. The research is intended to be useful to academics, composers and performers and has the aim of creating a new, published resource that will become an educational and creative tool for future use for all.

From the start of this project and whilst carrying out the research, playing the bass clarinet, analysing, talking to other performers and working with composers on new works, it was clear to me that one aspect of this study that should be emphasised is that multiphonics



are technically difficult to understand and to master. They are a technique that needs to be handled with great care by both performers and composers. This is clearly expressed by the bass clarinetist Harry Sparnaay in the quotation at the start of this introduction<sup>5</sup> and it is important to take account of this fact both in relation to and beyond this research. This project, whilst looking into new and original ways of notating multiphonics, will also discuss and discover how accurate or inaccurate and how stable or unstable multiphonics can be.

Crucially, the use of spectral analysis to analyse multiphonics graphically reveals to the performer how the bass clarinet actually works. To execute any multiphonic accurately, a performer has to have at least some sort of understanding about the acoustics of the instrument. In terms of the technical teaching of bass clarinet at all levels, it is very noticeable that although a performer spends many years trying to obtain the perfect embouchure and the perfect sound, the physics or harmonic aspects of the instrument are rarely explained. For multiphonics however, the perfect embouchure and the perfect sound have to be disregarded to some extent, as each multiphonic and each harmonic produced from a standard fingering require a versatile and flexible embouchure. In addition to having this degree of flexibility, a performer also needs to understand just how the acoustics and the harmonics of the instrument work. Chapter three, which is about Type One multiphonics, explains the importance of learning these details in the context of an analysis of how important the harmonic series is for the bass clarinet.

It is also important to draw comparisons with other instruments when talking about multiphonics. It is possible for a performer executing multiphonics of either Type One (chapter three) or Type Two (chapter four) to compare the bass clarinet to a brass instrument. On a brass instrument, to pitch and play a note the performer only has three or

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<sup>5</sup> Harry Sparnaay. Interview with Sarah Watts, Barcelona, 28 May 2011.

four valves, or a slide. A brass player must have an idea of how the note sounds, how tight or loose to prepare the embouchure and how much air pressure to use in order to attack and produce the note perfectly. If the embouchure and airflow are incorrect then the note will split. The same principle should be adhered to when attempting any multiphonic. Due to the instability of all multiphonics and in the case of Type Two multiphonics, the pitching of the highest audible note, the placing of the embouchure and the amount of airflow will cause the multiphonic to sound correctly. If a performer misjudges this, a multiphonic will be very likely to split, sound as a dull thud or simply just not happen.

Another instrument I have used to help composers understand multiphonics is a pianoforte (or any keyboard). It is very important to realise that a multiphonic chord will not sound as a piano chord. If a chord is played on a piano then each note of the chord will sound at more or less the same dynamic. With a multiphonic chord, different things will happen. A set of frequencies (sometimes harmonic, sometimes inharmonic) will sound above the fundamental (lowest audible note). Each of these frequencies will sound at a different decibel level and often the fundamental will not even be the strongest. The most important frequency in terms of successful execution is always the highest frequency with the strongest decibel level. There will be many other frequencies present in this chord. Some frequencies will be audible to the human ear and some will be inaudible. Some frequencies will filter in and out, whilst others will always be present. Some frequencies will disappear in some performance spaces and on some instrument set-ups, whilst in the same situations other frequencies will appear. Whilst my charts aim to convey the fundamental and highest note alongside other surrounding audible frequencies, it is important that composers (and performers) are always aware of possible instabilities that can still occur when trying to execute multiphonics.

One of the purposes of the project has been to commission a new set of études that will be a resource for composers who are looking for good examples of multiphonic writing in a composition. These new études, together with a selection of other new multiphonic pieces, can be found in chapter six. As there are very few methods to aid performers in the practice of multiphonics, the études will also provide other players and students with material that they can perform and can also use to develop their overall control, knowledge and technique in the performance area of multiphonics.

The aim of this research is to create a new and up-to-date comprehensive resource and original and accurate charts for both performers and composers in a way that is useful and that will encourage both parties to experiment further with their use. Throughout the project, the research will highlight the strengths and weaknesses of multiphonics – in relation to their stability when playing them and the problems and risks that may always be linked with using them (factors such as instrument set-up, atmospheric conditions and acoustics can affect the success of production).

## Chapter 2

# A background to multiphonics and their use in existing compositions

Multiphonics started to appear in bass clarinet compositions before the emergence of specialist bass clarinet multiphonic research and analysis. The explosion of the popularity of the bass clarinet as a solo instrument in the 1970s and 1980s prepared the way for the experimentation with and the development of contemporary techniques for the instrument. The repertoire from this period onwards includes multiphonics that are both notated and implied by various forms of graphic notation. Some of the earliest examples of multiphonic usage in the repertoire comes from the influence of the Dutch performer Harry Sparnaay, who became a highly acclaimed soloist during the 1970s, following his success in gaining first prize at the 1972 International Gaudeamus Performers Competition. One work that Sparnaay singles out as an outstanding example of an early solo repertoire that uses multiphonics is *Solo Identity 1*<sup>6</sup>, by the Dutch composer Jos Kunst. This work, composed in 1972, gives an instruction for a long, low tone, ‘passing into a chordal sound<sup>7</sup>’, and also provides instructions for a free choice of multiphonics to be played, asking for high, medium and low options, depending on the indications in the score. Kunst reworked *Solo Identity 1* into a new work for bass clarinet and piano in 1973 called *XX1:3. No Time at All*.<sup>8</sup> The same requests for a chordal sound and free-choice multiphonics also appear in this score. Figure. 2.1 shows an example of the request for a chordal sound in *Solo Identity 1*:

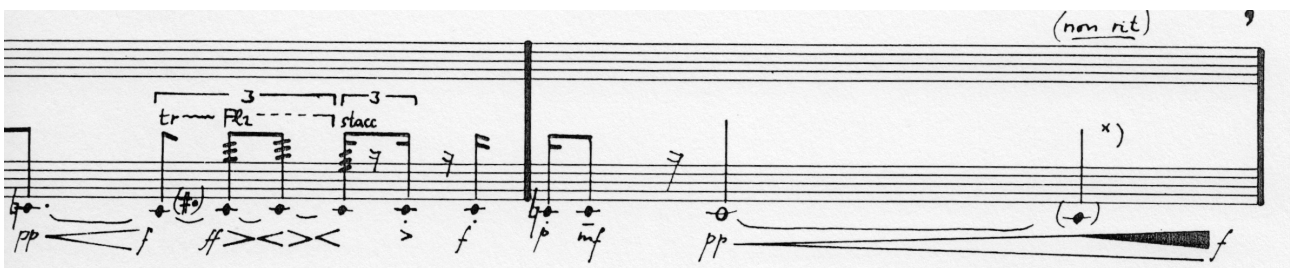
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<sup>6</sup> Jos Kunst. *Solo Identity 1*, Amsterdam: Donemus 1972.

<sup>7</sup> Jos Kunst. *Solo Identity 1*, Amsterdam: Donemus 1972. p.4

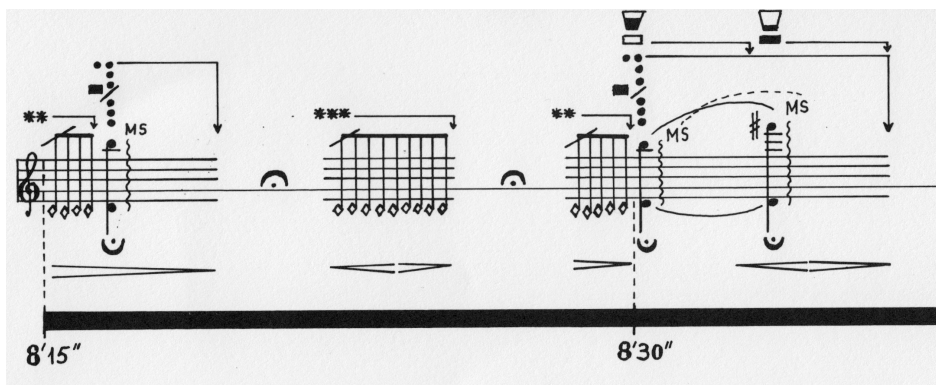
<sup>8</sup> Jos Kunst. *XX1:3. No Time at All*, Amsterdam: Donemus 1972.

Fig. 2.1: A 'chordal' sounding multiphonic in *Solo Identity 1*, by Jos Kunst.



In 1974 Enrique Raxach wrote *Chimaera*<sup>9</sup> for bass clarinet and magnetic tape. The final line of this work contains some of the earliest notated multiphonics with a fingering guide above the notes. Figure. 2.2 shows this example:

Fig. 2.2: Notated multiphonics in *Chimaera*, by Enrique Raxach



Important core repertoire pieces from the 1980s still favoured a more graphic and free choice for composers using multiphonics. *Itou*,<sup>10</sup> by the French composer Pascal Dusapin written in 1985 contains graphically notated multiphonic indications between bars 54–63.

Iannis Xenakis wrote *Echange*<sup>11</sup> in 1989 for bass clarinet and 13-piece ensemble. The composer requests that towards the end of the piece the performer plays the 'lowest split

<sup>9</sup> Enrique Raxach. *Chimaera*, Amsterdam: Donemus. 1974

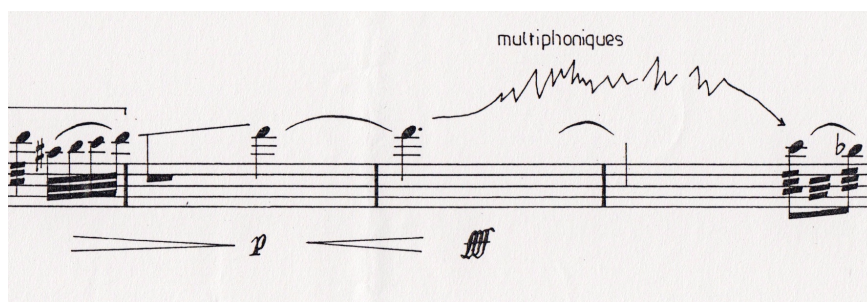
<sup>10</sup> Pascal Dusapin. *Itou*, Paris: Salabert. 1985

<sup>11</sup> Iannis Xenakis. *Echange*, Paris: Salabert. 1989

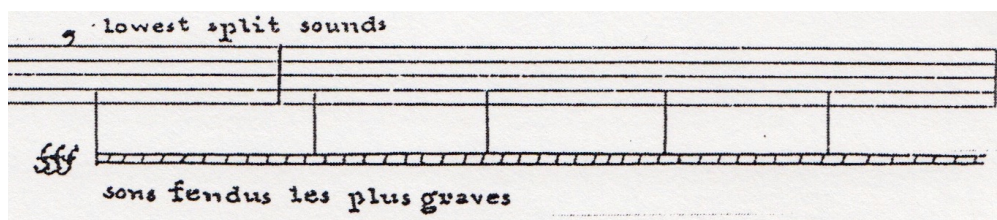
sounds', and the notes are notated in a graphic form. This implies that Type One multiphonics (see chapter three) are to be used on the instrument's lowest notes.

Fig. 2.3 shows an example of the request for multiphonics in *Itou* and Fig 2.4 shows an example in *Echange*:

**Fig. 2.3: Graphic notated multiphonic indications in *Itou*, by Pascal Dusapin**



**Fig. 2.4: Graphically notated multiphonics in *Echange* by Iannis Xenakis**



It is important to make reference to the work *Anubis, Nout – two pieces for contrabass clarinet*,<sup>12</sup> written in 1983 for Harry Sparnaay by the French composer Gérard Grisey. The second piece *Nout*, uses notated multiphonics with fingerings given in the performance instructions. The Dutch composer Gus Janssen explored the natural overtones of the instrument in his 1985 composition *Sprezzatura*.<sup>13</sup> The multiphonics are all notated and need to be controlled by embouchure manipulation using a mixture of standard fingerings

<sup>12</sup> Gérard Grisey. *Anubis Nout*, Milan: Ricordi. 1983

<sup>13</sup> Gus Janssen. *Sprezzatura*, Amsterdam: Donemus. 1895

and non-standard fingerings. Performance notes indicate which fingers to use for tremolos in the multiphonics.

There are some excellent examples of multiphonics by the Italian composer Salvatore Sciarrino. His chamber opera *Luci mie traditrici*<sup>14</sup> (1996–1998) uses both notated multiphonics and multiphonic glissandos that are achieved by manipulating embouchure pressure to obtain a spectral sliding effect between the upper harmonic partials. This technique is also used in his 1997 trio for alto flute, cor anglais and bass clarinet *Muro d'orizzonte*.<sup>15</sup>

A major work that uses the multiphonic charts of Henri Bok is *Pli-Ombre*<sup>16</sup>, by the Vietnamese composer Nguyen Thien Dao. This piece was written in 1985, which was before Bok's *New Techniques for Bass Clarinet* was published. Dao worked on this composition with Bok in a close collaboration at a time when Bok was working on both his book and his new charts. This resulted in a piece in which the notated multiphonics are a success and the charts are understood and used well by the composer. The piece uses 28 different notated multiphonics, and the composer is aware that they are notated at written pitch as he puts an 8ve indication above them. *Pli-Ombre* is a good example of how the best results with notated multiphonics can be achieved from a piece as the result of the composer working directly with a performer, and it set a new, groundbreaking precedent in the area of bass clarinet multiphonics. The work also contains free-choice, graphically written multiphonics. Figure 2.5 shows an example of the composer's use of Henri Bok's charts:

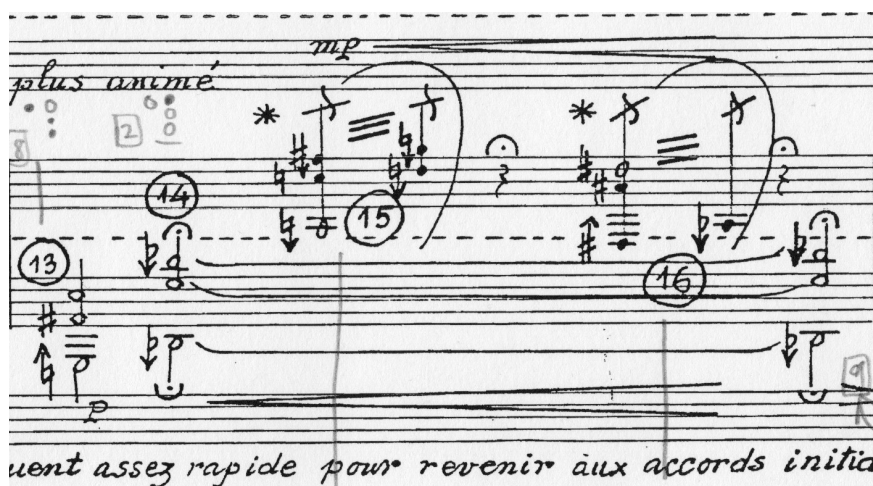
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<sup>14</sup> Salvatore Sciarrino. *Luci Mie Traditrici*. Milan: Ricordi 1996-1998

<sup>15</sup> Salvatore Sciarrino. *Muro d'orizzonte*, Milan: Ricordi. 1997.

<sup>16</sup> Nguyen Thien Dao. *Pli-Ombre*, Paris: Salabert. 1985.

Fig. 2.5: An example of notated multiphonics in *Pli-Ombre*, by Nguyen Thien Dao



The Swiss bass clarinetist Ernesto Molinari is a performer who has influenced many composers in the area of contemporary solo bass clarinet writing. *Assonance II*<sup>17</sup>, by Michael Jarrell was composed in 1995 as part of a series of pieces called *Assonance* for solo instrument or ensemble. By the 1990s more works were featuring notated multiphonics with fingering guides; the last lines of *Assonance II* feature such notations. Other works that use notated multiphonics include *Come dal Nulla*,<sup>18</sup> for solo bass clarinet (1993) by Ada Gentile, *Sequenza 9c*,<sup>19</sup> by Luciano Berio for solo bass clarinet (1980, adapted for bass clarinet 1998) and *Oi Kuu*,<sup>20</sup> for bass clarinet and cello (1990) by Kaija Saariaho.

As mentioned in chapter one there are two types of multiphonics. Type One multiphonics, which are based on standard fingerings for the lowest tones on the bass clarinet will be explored in chapter three. Type Two multiphonic possibilities (created by special

<sup>17</sup> Michael Jarrell. *Assonance II*, Paris: Editions Henry Lemoine, 1995

<sup>18</sup> Ada Gentile. *Come dal Nulla*, Milan: Ricordi, 1990

<sup>19</sup> Luciano Berio. *Sequenza IXc*, Vienna: Universal Edition, 1980 (adapted for bass clarinet 1998)

<sup>20</sup> Kaija Saariaho. *Oi Kuu*, Copenhagen: Edition Wilhelm Hansen, 1990



fingerings) are numerous in terms of fingerings, timbral texture and variety, and are fully explored in chapter four.

Various analyses of multiphonics that resulted in the publication of resources by performers such as Henri Bok<sup>21</sup> in 1989, Philip Rehfeldt<sup>22</sup> in 1977, Harry Sparnaay<sup>23</sup> in 2011 and an internet resource by Michael E Richards<sup>24</sup> in 1996 currently exist. These publications contain information about analysis, including spectral analysis and numerous ways of categorising and listing fingerings and notations for bass clarinet multiphonics. A performer of new music will find that a large percentage of new music will contain one or more multiphonics of various types. Unfortunately, the vast majority of these new works will have problems with the multiphonics and they will not sound as notated. Some charts are not transposed into the standard written key of B flat but remain in the sounding key of C. As this is not clearly stated at the start of the set of charts, composers often miss this fact, which results in transposition errors in compositions. Other problems in various charts include problematic fingerings and problems in compositions, including multiphonics that just appear as a chord in musical compositions without any indication as to what fingering to use. Over the past few years, players and composers have become disillusioned with trying to play and notate multiphonics accurately. This has often led to composers relinquishing the choice of which multiphonics they would like in the music and passing the responsibility to performers to choose based on one note that will be aurally present in the chord. At times, this is an important aspect of the music; however, the field of multiphonics

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<sup>21</sup> Henri Bok. *New Techniques For Bass Clarinet*, Paris: Original Edition, Salabert 1989, special limited edition, self-published. 2004.

<sup>22</sup> Phillip Rehfeldt. *New Directions for Clarinet* University of California Press, 1977, republished Scarecrow Press. 1994

<sup>23</sup> Harry Sparnaay. *The Bass Clarinet: A personal History*, Barcelona: Periferia Music. 2011

<sup>24</sup> E Michael Richards. *The Clarinet of the Twenty First Century*, [www.userpages.umbc.edu/~emrich/clarinet21.html](http://www.userpages.umbc.edu/~emrich/clarinet21.html) 1990-2000 23rd August 2013

is large, and there are many different multiphonics that have many different characters and qualities. The timbres produced by a multiphonic are vast and can fit into any type of music. Some appear harmonic and others appear very microtonal and inharmonic. Some are beautiful and gentle, whilst some are harsh and grotesque in character. Some can be played at any dynamic, but others can only be played loudly and many can only be played quietly. It is important that resources are reliable and charts are accurate so that a composer has the freedom to have a choice of using the multiphonic which will be best suited to the composition in question.

Spectral analysis software can provide accurate results when it breaks down the partials in each fingering option. This has been explored in the past using various resources, and the software *Audiosculpt* (a spectral analysis software from IRCAM, France) has been used in this research to reanalyse all past fingering charts and previously uncharted fingerings and to aid the compilation of new charts. Spectral software was not freely available during the 1980s during the compilation of numerous past charts such as those of Rehfeldt and Bok. Today, however, various types of spectral analysis software are widely available, which enables past charts and fingerings to be checked and reanalysed.

One of the first examples and explanations of multiphonics appears in Bruno Bartolozzi's *New Sounds for Woodwind*,<sup>25</sup> 1967. This book looks into the theories of multiphonic production, especially in relation to the bassoon, clarinet, flute and oboe. The bass clarinet, however, is an independent instrument with its own acoustic features, and it is important not to treat the bass clarinet as a clarinet. The addition of a curved neck, larger mouthpiece and reeds, additional keys, extra bottom notes and a curved metal base with a flared bell are all individual characteristics of the bass clarinet and, in acoustical terms,

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<sup>25</sup> Bruno Bartolozzi. *New Sounds for Woodwind*, Oxford: Oxford University Press. 1967.

provide the set-up that gives the bass clarinet its unique sound. Since Bartolozzi's book makes only a passing reference to the bass clarinet and does not look in detail at the instrument, I have chosen not to make further reference to this book in relation to multiphonic charts.

The best-known contemporary bass clarinet resource to date is Henri Bok's *New Techniques for Bass Clarinet*,<sup>26</sup> 1989/2004. This book contains several sections about multiphonics and analysis and notations for 112 individual fingerings, as well as examples of trill and tremolo options for bass clarinet multiphonics. There are problems with the multiphonic analysis and charts in the book, which has led to confusion for composers and to inaccuracies when using them in modern compositions. The multiphonics are not transposed into the written key of B flat, but are printed in the sounding key of C; according to Bok, in an interview in 2013<sup>27</sup>, this was at the request of the publisher Salabert. He also claims that it is clearly stated at the start of the book that all multiphonics are in the sounding key, but upon reading the book, the wording is vague and has led to misunderstandings. The multiphonics are notated in treble clef, but at sounding pitch, i.e. sounding a ninth lower than written. This has also led to misunderstandings by composers, as the multiphonics appear to look as if they sound an octave lower than how they are written. In the same interview, Bok states that it should be obvious to a composer who has researched bass clarinet notation and technique that they are at sounding pitch and that they should be aware of this before writing. In reality, however, it should never be assumed that this is the case, and it has been proved that in many compositions (as also seen in later chapters in this resource) composers have been confused by both the transpositions

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<sup>26</sup> Henri Bok. *New Techniques For Bass Clarinet*, Paris: Original Edition, Salabert 1989, special limited edition, self-published. 2004.

<sup>27</sup> Henri Bok. Telephone interview with Sarah Watts, 10 February 2013.

and the notations in this book. As with every contemporary technique, clear instructions and rules should always be stated very clearly.

Furthermore, on occasions some fingerings appear twice with different notations. This has led to some composers and performers dismissing the charts as unchecked and inaccurate. As explained in chapter four, in this publication on Type Two multiphonics, some fingerings can produce two different chords by manipulating the embouchure in different ways. Experience has shown that these problems have led to serious harmonic errors in new pieces in which, for instance, a series of multiphonics has been written where a pedal note has been intended. Many times I have come across compositions in which, when using the fingerings given in the charts, the pedal note is either different or changes between multiphonics, thus defeating the concept and compositional structure of that passage of music.

It is very important to state that at the time that Bok completed this set of charts, very little official research into bass clarinet multiphonics had taken place. Limited numbers of multiphonics are listed, such as those in *New Directions for Clarinet*<sup>28</sup> by Philip Rehfeldt, but the charts by Bok were the first lengthy set to be analysed, notated and published. At the time of this analysis, no technology was available. All the multiphonics were analysed by ear. This was done by Bok and then rechecked by colleagues who specialised in aural analysis.

*New Directions for Clarinet*, by Philip Rehfeldt (1977, first edition published by California Press and 1994, second edition published by Scarecrow Press) is mainly aimed at the clarinet, but there are sections that concentrate solely on bass clarinet and it does contain a list of separate bass clarinet multiphonics which are clearly notated and for the most part fairly accurate.

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<sup>28</sup> Phillip Rehfeldt. *New Directions for Clarinet*,  
USA: Scarecrow Press, 1994, chapter 3.

Rehfeldt's work with multiphonics goes back to the early 1970s and is mainly centred on the B flat clarinet. At that time a Buffet bass clarinet was used for the bass clarinet multiphonics, but this was a Buffet<sup>29</sup> without the low note extension, which means that the lowest three semitones of C, C sharp and D were not available. As this effectively shortens the actual length of the bass clarinet, it also limits the number of achievable multiphonics and the overtone possibilities which explains why some of the listed multiphonics in the Rehfeldt book do not always sound completely accurate. The author has also stated that by the time the second edition was written it was very obvious that the bass clarinet had become very attractive to contemporary composers – perhaps even more so than the standard B flat clarinet<sup>30</sup>.

There is an abundance of internet resources on clarinet multiphonics; however, there is very little information online about bass clarinet multiphonics. The only fairly substantial online resource is a publication by E. Michael Richards called '*The Clarinet of the Twenty First Century*'<sup>31</sup>, 2013. A section of this publication is dedicated to the bass clarinet, and a chapter in this section does look into the analysis of bass clarinet multiphonics and has a brief explanation of spectral analysis. The multiphonics for bass clarinet listed and available on the website are very limited (only a very small range of multiphonics are given), and although what is listed has a lot of detail on how well the multiphonics sound, the dynamic contrast, the amount of air in the sound and the stability of the multiphonic, this chart is not extensive enough to be considered useful to composers who will want and do indeed require a more detailed guide in terms of the range of fundamental notes. A

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<sup>29</sup> Buffet is a French clarinet manufacturer. Other makes of bass clarinet that are used today include Leblanc, Selmer, Uebel and Yamaha. This research focuses on Bohem system bass clarinets used by these makers.

<sup>30</sup> Personal correspondence with Phillip Rehfeldt, 6 January 2013.

<sup>31</sup> E Michael Richards. '*The Clarinet of the Twenty First Century*', [www.userpages.umbc.edu/~emrich/clarinet21.html](http://www.userpages.umbc.edu/~emrich/clarinet21.html) 1990-2000. 23rd August 2013

more extensive set of charts has been notated, but access is not given to them on the website. I (and other performers and composers) have been unable to get an answer from the composer in response to my request to view the entire set of charts despite numerous attempts to contact him via the email link on the website. The presentation of these charts is untidy, they are very crowded and the fingerwork system is not as clear as on some other charts.

The most recent publication on the bass clarinet in general is Harry Sparnaay's *The Bass Clarinet: A Personal History*.<sup>32</sup> This book contains an excellent chapter that looks at bass clarinet multiphonics and has the most reliable set of charts yet, which has a new experimental style of graphic notation for multiphonics. The multiphonics are all analysed using the SMS Tools software developed by Xavier Serra and the Music Technology Group (MTG) of Pompeu Fabra University. The charts are very clearly presented in written pitch (a ninth higher than sounding), and are all notated in the bass clarinet's written key of B-flat, which eliminates all past transposition confusions. The charts contain guides on the stability of each multiphonic and on the embouchure flexibility needed for each one. There are only around 98 listed, however, and, because the guides are part of a general book, only the basics of multiphonics have been considered. Despite this, Sparnaay very clearly states in the book that using his proposed (graphic) notation will mean that there is an opportunity for many more multiphonic possibilities. Sparnaay also emphasises that these are his results, with his set-up, and that each multiphonic may be subject to some changes when executed by others. The graphic notation allows for a degree of flexibility with each multiphonic whilst allowing the important frequencies to be well charted and obvious to composers and performers.

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<sup>32</sup> Harry Sparnaay. *The Bass Clarinet: A Personal History*,  
Barcelona: Periferia Music, 2011. p. 130 – 154.

It is important to look at the different ways in which multiphonics have been categorised and notated in the past. All of the charts mentioned above notate and categorise in different ways. Henri Bok's charts in *New Techniques for Bass Clarinet* are categorised in fundamental order, as are E. Michael Richard's charts in his internet resource. Harry Sparnaay has chosen to categorise his multiphonics in a fingering-based systematic order looking at close neighbouring finger systems. Philip Rehfeldt has categorised his multiphonic charts into different sections based on dynamic and reliability factors. In the figures below are examples of a random multiphonic from each of the above four players' charts, which give an idea of the different notations that are currently available.

**Figure 2.6: An example from Henri Bok's charts**

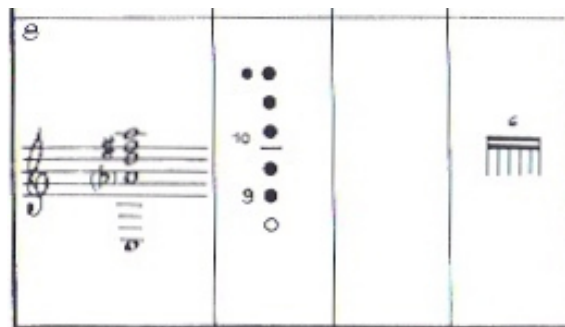
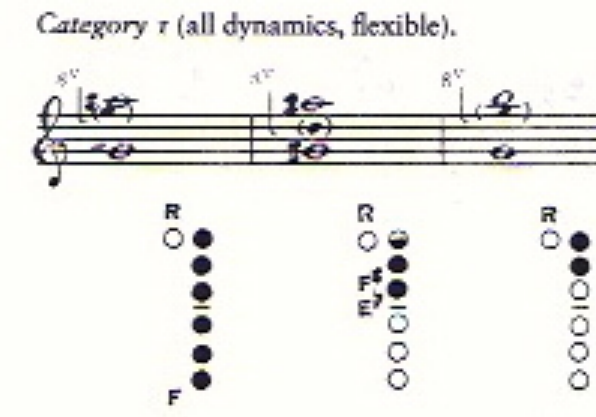


Fig. 2.1 shows that the Bok notation is at sounding pitch; in written pitch, the multiphonic would read an octave higher. Whilst it is clear to a performer that the fingering indicated to the right of the notation would not result in a sounding low C, a composer who does not have extensive knowledge of the instrument may miss this key fact. The use of a numbering system for side keys is seen on these charts, and this is discussed in further detail in later chapters. In this chart, Bok also gives an idea of any pulsating that the multiphonic may or may not produce when being played – this is signified by the sextuplet notation.

**Figure 2.7: An example from Philip Rehfeldt's charts**



The example in Fig. 2.2 is from a section of multiphonics in the Rehfeldt charts that should sound at all dynamic levels. It can be seen in bar one that the fundamental G sounds slightly flat and that the composer uses a system of '+' and '-' symbols to signify approximate quarter/eighth tone notation. The multiphonics here are notated at written pitch, and partials in black should sound an octave higher. Rather than using a number system for side keys, Rehfeldt has opted to use 'R' for register key and the names of the notes for the side and little finger keys.



Figure 2.8: An example from E. Michael Richard's charts

Handwritten musical chart for a trill. The top part shows a staff with notes and accidentals, including a circled note with an upward arrow and a circled note with a downward arrow. Below the staff is a grid of squares representing fingerings for three notes. At the bottom, there is a list of dynamic and technical markings:

75	80	86
pp-m	mp-f	m-l
s-a	s-ba	s-l
ri	r3	rl
tran	rich	elic
bel		thi
bot	bot	
top		

Fig. 2.3 shows that the multiphonics in Richard's charts are at written pitch. Arrows provide information on whether the note is high or low in pitch. The information below the charts supplies details about dynamic possibilities, stability, response, timbre and texture, the balance of frequencies and technical difficulty. The example above is the same size as on the website, so we can clearly see that there is a lot of detail, but it is very hard to read.

Figure 2.9: An example from Harry Sparnaay's charts

Proposed fingering	Sounding result	Proposed notation	Stability	Tonguing	Dynamics	Embouchure	Other remaining remarks
65 13 ●●● ○ ○ ○			2	2	<i>p</i> → <i>mp</i>		Trill with MF66 and 2nd finger of the left hand

We can see that in Sparnaay's charts in Fig. 2.9 there is a lot of information for each multiphonic. The fingering system is the same as Bok's, and he uses the numbering system for side keys. Sparnaay writes down a sounding result, but he has also invented an innovative notation that uses a box in the multiphonic to allow for flexibility from player to player. There is also an indication of stability, the response following the initial attack using the tongue, the dynamic possibilities and embouchure advice, and there are also trilling options.

A summary of the current publications discussed so far can be seen in Fig. 2.10, which lists the resources and analytical information, and highlights the positives and negatives of each publication. It should also be observed that without exception all of the resources available to date that provide information about bass clarinet multiphonics are not focused solely on exhaustive and comprehensive multiphonic guides. The information about multiphonics in these publications forms part of a general guide to the overall history and techniques of multiphonics, and supplies more general information about the clarinet, the bass clarinet and, in terms of Bruno Bartolozzi's *New Sounds for Woodwind*, general woodwind.

**Figure 2.10: Current available resources**

Name of resource and Author	Analysis method	comments
<i>New Sounds for woodwind</i> , first published in 1967, Bruno Bartolozzi. Oxford University Press.	Theoretical and aural. No technology used.	Has no reference or information directly related to bass clarinet.

Name of resource and Author	Analysis method	comments
<p><i>New Directions for Clarinet</i>, Philip Rehfeldt</p> <p>First Edition published by California Press in 1977, republished by Scarecrow Press in 1994.</p>	<p>Aural.</p> <p>No technology used.</p>	<p>Bass clarinet with lowest note E flat and not low C bass clarinet used for analysis.</p> <p>Categorised into several different categories such as dyads and dynamic possibilities.</p> <p>Not all multiphonics in this resource appear to be transposed into the written key of B flat</p>
<p><i>New Techniques For Bass Clarinet</i>, Henri Bok.</p> <p>First published by Salabert in 1989, self published edition reprinted in 2004.</p>	<p>Aural.</p> <p>No technology used.</p>	<p>Charts are untransposed and in the sounding key Dynamic indications and embouchure pressure guides are indicated.</p> <p>Multiphonics categorised by fundamental pitch order.</p>
<p><i>The Clarinet of the Twenty First Century</i>, E Michael Richards.</p> <p>Internet resource.</p> <p>1990-2000.</p>	<p>Spectral Analysis.</p> <p>Exact spectral analysis programme information not given on website.</p>	<p>Charts are transposed in the written key of B flat.</p> <p>Much information including stability, dynamic possibilities, response and timbre is given.</p> <p>Only a limited number available online. Author does not respond to emails when trying to contact for further information and details.</p>

Name of resource and Author	Analysis method	comments
Harry Sparnaay - <i>The Bass Clarinet: A Personal History</i> , Harry Sparnaay Periferia Music, 2011.	Spectral Analysis using SMS Tools' software developed by Xavier Serra and the Music Technology Group (MTG) of the Pompeu Fabra University.	Charts transposed into the written key of B flat.  Much information given including stability, dynamic possibilities, embouchure pressure needed, response, alternative notations an trilling options.

### **Feedback from performers and composers on the reliability and usability of bass clarinet multiphonics**

The field of multiphonics in the area of bass clarinet performance and composition has been an area eliciting wide views, opinions, wants and needs. The general consensus is that composers are frustrated by inaccurate, misleading and confusing charts which result in their compositions including multiphonics that it is not possible to play accurately. Likewise, receiving works that are impossible to play as the composer intended has become a major problem for performers. Whilst carrying out this research, I asked both composers and performers to provide me with feedback about their experiences with multiphonics. I also interviewed the Dutch bass clarinetists Henri Bok and Harry Sparnaay, who have been and still are amongst the most important pioneers of the contemporary bass clarinet. Using email and various forms of social media, I asked for answers to the following questions.

#### **For composers:**

Have you written a piece containing multiphonics? What resources did you use? Were the multiphonics working as they appeared in the charts and if inaccurate how did you and the performer solve any problems?

**For performers:**

Have you had a piece written for you or come across an existing piece that contains multiphonics that are impossible to play? Do you know which resource they came from? How did you get around any problems?

The majority of composers questioned used Henri *Bok's New Techniques for Bass Clarinet*, but some composers used Philip Rehfeldt's *New Directions for Clarinet*. A few composers were also aware of Richard's web resource '*The Clarinet of the Twenty-First Century*', and made reference to multiphonics on the website. Recently, composers have been discovering Harry Sparnaay's 2011 publication and his selection of workable multiphonics. The majority of composers and performers that gave feedback reported that they had indeed written or received pieces that had multiphonics that would not work as indicated in the charts.

The British composer Stephen Mark Barchan commented that he used Philip Rehfeldt's resource guide and that many of the multiphonics did not work in the sense that they did not produce a chord and instead often produced a single pitch with a dull sound. Not only did the multiphonics not all work, but more often than not the pitches given in the book were inaccurate. Barchan solved this problem by working directly with a performer; when he found a multiphonic fingering he liked he would notate it by using his ear and a piano for reference and by taking note of dynamic possibilities and fingering<sup>33</sup>. By way of defence of Rehfeldt's resource, George Nicholson, composer and Head of Composition at Sheffield University, had used this guide without the performer he was working with mentioning any

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<sup>33</sup> Personal correspondence with Stephen Mark Barchan, 16 January 2011.

problems, and he said that the Rehfeldt classifications for factors such as ease of production and dynamic resistance were very useful<sup>34</sup>.

Ryan Molloy, from Ireland, was just one of the composers who mentioned that discrepancies in pitch and transposition were annoying. The composer said, 'The most annoying thing was the discrepancy in the pitch you expected (either because of the notated version in the book or the sound they made on the CD) and that which was actually produced. Also including the inconsistency between transposed versions and 'at pitch' notations<sup>35</sup>.'

The composer Marc Yeats wrote *Vox* for solo bass clarinet in 2002 using Henri Bok's *New Techniques for Bass Clarinet* for the multiphonics, which proved problematic. Yeats told me that in his experience of using these charts:

'The multiphonics had their partials notated to give an idea of the outcome of sound – this was inaccurate and misleading<sup>36</sup>.'

Composers who had a direct collaboration with performers reported the best results when using multiphonics. Robert Fokkens was one such composer, who commented that he worked directly with a performer to choose multiphonics that produced the right sound and effects he was looking for. This approach meant that all of them were successful, but the composer did mention that during performance the multiphonics could become unstable due to their risky nature<sup>37</sup>.

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<sup>34</sup> Personal correspondence with George Nicholson, 16 January 2011.

<sup>35</sup> Personal correspondence with Ryan Molloy, 17 January 2011.

<sup>36</sup> Personal correspondence with Marc Yeats, 16 January 2011.

<sup>37</sup> Personal correspondence with Robert Fokkens, 20 January 2011.

John Hails, a composer based in Edinburgh wrote *Duo 1*<sup>38</sup> for two bass clarinets for Heather Roche and me in 2010. The multiphonics were chosen using the Bok and Rehfeldt guides as reference points in collaboration with Heather Roche. It was noted by the composer that not all of the multiphonics worked, but by cross-referencing multiphonics in both books and working with a performer a workable set of multiphonics was chosen for the composition<sup>39</sup>. These were then tried on my instrument to double-check that all of the chosen multiphonics were workable on both players' instruments (one being a Buffet and one being a Selmer). The requirements of the harmonic nature of John's composition meant that it was vital that the multiphonics worked perfectly on both instruments. *Duo 1* shows that the availability of the performers and their willingness to work directly with this composer resulted in a very successful duo with working multiphonics.

Some composers' questionnaires indicated that they not confident using multiphonics in pieces. One of the main reasons for this was that composers did not trust charts. Other comments included the fact that writing using multiphonics was difficult because to do this a composer really needs to know specific things about them, including how they work and how to use them effectively. Many composers have chosen to use vague notation and have opted for a general effect in that it is up to the performer to choose an appropriate multiphonic.

The composers' feedback was mixed in relation to working with problems surrounding inaccurate multiphonics. Daniele Di Maggio commented that he had used a mixture of Bartolozzi's theory and performers' experience when writing. Composer/performer

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<sup>38</sup> John Hails, *Duo 1* for two bass clarinets. self-published. 2010

<sup>39</sup> Personal correspondence with John Hails, 16 January 2011.

collaboration had helped to achieve the results he was looking for, but whilst the multiphonics were close to being accurate, they did not match what was supposed to sound note for note<sup>40</sup>. At times, some of the performers chose to rectify problems themselves, but sometimes this did not fully satisfy the composer. Another composer, Scott McLaughlin commented that:

‘after several years of attempting to use charts with players, by the time I did a piece I was unwilling to go through the frustration of trying to communicate via charts<sup>41</sup>’.

There were two areas of potential discussion points and thoughts relating to decisions for future new charts that opened up trains of thoughts and options. These were 1. How many frequencies should one notate in a multiphonic? and 2. How accurately does one notate microtones? Ryan Malloy noted questions and suggestions relating to the problems of actual notated pitch and the instability of the multiphonic spectra, especially in high frequencies. Malloy suggested that when notating multiphonics one should narrow this down to exactly what is audible, but should not go into too much detail with regards to the very high harmonics, as precise pitch determination by even the most avid listener would prove difficult<sup>42</sup>.

The issue of notating to either quarter tone or eighth tone pitch was also a factor that was of interest to composers. Questions arose as to how accurately it would be possible to notate frequencies in multiphonics. Some composers who work in an electroacoustic field wanted more information in the future about the overall spectral build of each multiphonic.

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<sup>40</sup> Personal correspondence with Daniele di Maggio, 21 January 2011.

<sup>41</sup> Personal correspondence with Scott McLaughlin, 16 January 2011.

<sup>42</sup> Personal correspondence with Ryan Molloy, 17 January 2011.



Patrick Nunn is one such composer, and he is interested in the use of sonograms to help analyse the minute details of each multiphonic:

‘Charts are inevitably a guide and only reveal a small part of the overall sound (which is why sonograms are crucial as part of the fuller picture – we often only hear certain pitches as an overall timbre and not as individual pitch components unless you have super human hearing). If a list of multiphonics could be devised that demonstrated the most prominent pitches (perhaps 5 or 6), which remain stable, which ones change, and demonstrate levels of quality/dynamics and the range available would be useful.<sup>43</sup>’

### **Performers:**

Without exception, all the performers I spoke to have had problems with the notation of pieces that contain multiphonics. Composer and performer collaborations do not always rectify problems that satisfy the composer’s original intentions fully. Bass clarinettist Lucy Downer had such an experience:

‘I’ve had a piece written for me by Nick Planas, which has 4 multiphonics at the end. He originally put in fingerings he had got from a chart – they produced some sort of chord, but not the ones he’d written, so I tried to find my own fingerings that would work, as he did want specific pitches rather than just a general multiphonic effect. That failed too, so eventually he decided to rewrite them and try again. He’s now written in fingerings which are basically just splitting a low note (Type One multiphonics)<sup>44</sup>.’

The guide that seems to create the majority of the problems as far as performers are concerned is Henri Bok’s book. In an interview in 2013, he explained that his research into multiphonics was amongst the first extensive and comprehensive analysis. This is an

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<sup>43</sup> Personal correspondence with Patrick Nunn, 17 January 2011.

<sup>44</sup> Personal correspondence with Lucy Downer, 15 January 2011.

important fact in this research, and it should also be noted that at the time Bok compiled his fingerings there was little in the way of other resources to help him. When asked about this choice of fingerings, Bok replied:

‘They were mostly my own. The point is that I didn’t receive much information at the time from my teachers. So I decided to start experimenting and of course I understood very well the working of the bass clarinet, the overtone series and the way things worked. So I started to experiment with the fingerings and write them down. The only thing I did was to look in the Rehfeldt book (but the first edition, not the 2003 edition where a chapter was added on bass clarinet). I also looked at clarinet multiphonic fingerings and tried them on the bass clarinet and adjusted them if needed. But mostly they were my own research <sup>45</sup>.’

It should also be noted that unlike the research in this project and that of Harry Sparnaay, Bok did not have the use of technology to help him in his analysis:

‘We are speaking about the 1980s. The book was published by Salabert in 1989 and it took me years to write that book. There was no technology available so what I did was use my ears to write all these pitches down. Then I consulted several pairs of ears and I remember I asked a few very good colleagues of mine who were specialists in ear training and solfège It was just the human ear<sup>46</sup>.’

Some performers noted that pieces sent to them by composers who had just used charts and had not collaborated during the compositional process nearly always contained problems when they tried them. Composers who spent time collaborating with performers had the most success. Rocco Parisi is one such performer. He said:

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<sup>45</sup> Henri Bok. Telephone interview with Sarah Watts, 10 February 2013

<sup>46</sup> Henri Bok. Telephone interview with Sarah Watts, 10 February 2013

'I didn't have problems with composers, because they contacted me before writing. For example with Luciano Berio in his *Sequenza IXc*<sup>47</sup> and Ada Gentile's *Come dal nulla*<sup>48</sup>.'

**Figure 2.11: Excerpt from *Sequenza IXc*, by Luciano Berio.**

The image shows two systems of musical notation for Luciano Berio's *Sequenza IXc*. The first system is a single staff with a bass clef, featuring a complex rhythmic pattern with notes beamed together. Handwritten annotations include a box labeled 'J', a circled '7' with '2+2+3' above it, and a circled 'III' with 'do#' above it. Performance markings include *mf*, *p*, and *mf* with a hairpin crescendo. A tempo marking of ♩ = 60 is present. The second system consists of two staves (treble and bass clefs) with a piano (*p*) dynamic. It includes circled Roman numerals 'IV', 'IV', and 'IV' above notes, and a box labeled 'K' above a note. A circled 'III' and 'IV' are also present. A tempo marking of ♩ = 50 is shown. A handwritten '5"' is written above a note.

**Figure 2.12: Excerpt from *Come dal Nulla*, Ada Gentile.**

The image shows a single staff of musical notation for Ada Gentile's *Come dal Nulla*. The notation is sparse, with notes and rests. Performance instructions include 's. d'eco' (sordina) above the first measure, and 'puls. lent. slow pulsations' above the second and third measures. Dynamics are marked as *pppp* (pianissimo) and *pp* (piano). There are also handwritten annotations, including a circled '1' and a circled '10'.

Both pieces work for different bass clarinets, providing evidence that collaboration works well and that multiphonics notated correctly can work for different players and different instruments. The multiphonics in both pieces are notated in different ways, but both have clear fingering explanations either above the notes (Berio) or with the detailed performance notes.

<sup>47</sup> Luciano Berio. *Sequenza IXc*, Vienna: Universal Edition. 1980. p.7.

<sup>48</sup> Ada Gentile. *Come dal Nulla*, Milan: Ricordi. 1990, p.1.

The majority of performers asked questions ended up disregarding multiphonics chosen by composers that were impractical, and used their own knowledge and fingerings to find alternatives. The Mexican performer Antonio Rosales wrote to me saying:

‘Well in my experience, multiphonic fingering charts or suggested fingerings for multiphonics in situ on the paper, are most of the time totally useless <sup>49</sup>.’

The general impression formed by considering performers’ feedback is that most performers are convinced that it is not possible to produce any set of charts that accurately works for every instrument and every player.

The British player Ian Mitchell is amongst a large number of bass clarinetists who have compiled their own sets of preferred and workable multiphonics. He said,

‘I sometimes refer to a very few books. However, I mostly work from my own (improvised) fingerings, or merely produce something from an ordinary clarinet fingering with a change of production rather than fingering<sup>50</sup>.’

Many of Mitchell’s pieces that involve multiphonics are realised in direct collaboration with composers and are usually based either around a fundamental pitch or are chosen when working with the composer to find one that has the timbre and effect that the composer is looking for. Mitchell also commented that:

‘Often I’m performing an improvisation and like to create multiphonics to see what comes out and where they might take me musically at that moment<sup>51</sup>.’

In May 2011 I interviewed Harry Sparnaay to ask for his advice on multiphonics and on how to reconstruct and re-notate multiphonics charts. At the time of interview, Sparnaay had recently published his new book. Sparnaay argued that composers must have a

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<sup>49</sup> Personal correspondence with Antonio Rosales, 25 January 2011.

<sup>50</sup> Personal correspondence with Ian Mitchell, 27 April 2011.









<sup>51</sup> Personal correspondence with Ian Mitchell, 27 April 2011.

degree of flexibility in terms of what they expect from performers who are trying to execute multiphonics:

'I think our task is to convince the composers that it is a very risky business, and it is a very insecure business. Because, even when I change my reeds or I play the next day when I am maybe a little bit tired, they are changing. So can you imagine when you are playing? And you are female and you are playing a Selmer with a crystal mouthpiece, the result can be completely different. And that he (the composer) has to accept. And I know for sure, believe me that you will get composers who say No. Forget these composers because, a composer has to be flexible. Also a good composer will listen to you<sup>52</sup>.'

Sparnaay's new set of multiphonic charts are currently the most accurate set in any published resource. The notation that he has developed allows for flexibility in performance; there are ninety-eighth published multiphonic possibilities that work on different models of bass clarinets. I was able to play all but one on my set-up, and feedback from other players has been positive.

**Figure 2.13: Excerpt from Harry Sparnaay's *The Bass Clarinet: A Personal History*<sup>53</sup>**

Proposed fingering	Sounding result	Proposed notation	Stability	Tonguing	Dynamics	Embouchure	Other remaining remarks
57 			4	4	<i>pp</i>		Same fingering as MF56, only change of embouchure. Very unstable!
58 			2	3	<i>mp</i> → <i>f</i>		Bisbigliando with the 4th finger of the right hand. Sometimes the C4 is very clearly audible

<sup>52</sup> Harry Sparnaay. Interview with Sarah Watts, Barcelona, 28 May 2011

<sup>53</sup> Harry Sparnaay. *The Bass Clarinet: A Personal History*, Barcelona: Periferia Music, 2011. P. 150

Sparnaay warned, however, that:

‘The problem with multiphonics is that you are making the multiphonic with your lip. Multiphonics I think are the most difficult and the most risky thing we have for our instrument because – and I hope I was clear in my book – it is your results when you are writing. And the book is working, I’m one hundred percent sure - but it is my result<sup>54</sup>.

Despite the success of these charts, even Sparnaay has problems with his own multiphonics on occasions:

‘Everything was made with the normal Buffet prestige bass clarinet and I changed in August to the Greenline Buffet. I like it really very much. And number 76 or 67 – I’d have to look in the book – it’s not working at all. I can’t do anything! It’s the same mouthpiece the same person, but a different material and number 76, I cannot play it myself and I wrote it! I played it on the tape. I cannot play it – not on this bass clarinet. So we are what I said - in Holland what we say – we are walking on slippery ice – with multiphonics<sup>55</sup>.’

Both composers and performers have referred to stability issues with multiphonics and the problems that different performance situations can have on them. A whole host of factors can and do affect multiphonics in performance for all players, including Harry Sparnaay:

‘So all the multiphonics work – I know because I’ve played the piece and yesterday in the concert after playing two other pieces one multiphonic with a high B did not come at all. So I kept on with the B without a multiphonic, because you know when you try to get a multiphonic sometimes you hear incredible noises, so I said OK it has to be soft so I played the B with no multiphonic. So I played the other multiphonics and that multiphonic

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<sup>54</sup> Harry Sparnaay. Interview with Sarah Watts, Barcelona, 28 May 2011

<sup>55</sup> Harry Sparnaay. Interview with Sarah Watts, Barcelona, 28 May 2011

was repeated at the end ... a little bit of water and the reed had gone too soft. And it is me! I made the multiphonics<sup>56</sup>.'

The relationship between the performer and composer has been highlighted throughout this chapter, and it is evident that composer and performer collaboration results in the most reliable compositions. As a performer, however, it has become apparent to me that we still need to educate and at times advise composers as to what the bass clarinet is capable of. It is not always possible for a composer to work in direct collaboration with a performer, and it must be realised by all performers that sometimes the basic facts about our instrument are not always known by composers. When I asked Bok about the confusion created by charts being in C and written at sounding pitch, he responded:

'This is a very important remark I am going to make: a composer who has studied and who is a knowledgeable composer should know about the ranges of the instruments, should know about instrumentation. The moment that you open the book, even if you forgot to read the introduction where it is stated, you look at the range and you should see what the notation is like and immediately you should understand as a composer that this is in C, because it is impossible to be in Bflat. Do you agree with that? I mean it is so obvious<sup>57</sup>.'

A point that is obvious to any performer who knows their instrument well, is not, however, always obvious to a composer writing for the instrument for the first time. Despite the existence of method books such as those by Bok and Sparnaay, and even by Volta<sup>58</sup>, there are still many composers, universities and libraries that do not have these resources. Many student composers are still taught with reference to outdated orchestration resources, and many very good and prominent established composers still use such

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<sup>56</sup> Harry Sparnaay, Interview with Sarah Watts, Barcelona, 28th May 2011

<sup>57</sup> Henri Bok. Telephone interview with Sarah Watts, 10 February 2013

<sup>58</sup> Jean marc Volta. *The Bass Clarinet Method*, Paris: International Music Diffusion, 1996.

resources as their main source of information. Many of these books advise that the bass clarinet only goes down to written low E flat, whereas nowadays the majority of soloists and orchestral players play as standard on instruments that go down to a written low C. This fact alone challenges the assumptions in Bok's statement.

It should be observed that in chapter five the multiphonics in the composition *Vox*<sup>59</sup>, from 2001 by Marc Yeats are discussed, reanalysed and reconstructed. Yeats is an example of an extremely knowledgeable composer who had done a lot of research before writing the piece. Every aspect of the piece apart from the multiphonics is very well written. Yeats had not realised, however, that the multiphonics were at sounding pitch in Bok's book. Bok continued:

'You look at a multiphonic in the book that I describe and you see that it can't be in Bflat notation because of the range. You look at it again and you say yes of course, I will have to transpose it. And if you miss that then you are not very educated or not very knowledgeable<sup>60</sup>.'

To summarise this chapter and the feedback received, the expectations for a new set of charts could include:

- i/ A working set of multiphonics for different makes of bass clarinet
- ii/ CD or MP3 audio samples
- iii/ Dynamic ranges
- iv/ Strong and weak descriptions (which multiphonics are easy and which are hard to execute)
- v/ Actual notated pitch so composers don't get confused
- vi/ Ease of production and time needed for sounding
- vii/ A spectral breakdown

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<sup>59</sup> Marc Yeats. *Vox* for solo bass clarinet, Glasgow: Scottish Music Information Centre. 2001/rev.2012

<sup>60</sup> Henri Bok.telephone interview with Sarah Watts. 10 February 2013



viii/ Trills and tremolo options

ix/ Difficulty indications

x/ Embouchure positions

xi/ Fingerings in a format that composers can use in scores

xii/ Quarter and eighth tone breakdowns

All of these factors were considered when I notated and analysed my new multiphonic charts. Chapter four shows my final notations and explains the final decisions that led to the the composition of the charts.

## Chapter 3

### Type One multiphonics and spectral analysis

This chapter looks into the methodology and technology used to analyse bass clarinet single tones and multiphonics. In order to effectively analyse, play, understand and accurately chart each Type Two multiphonic in chapter four and the final SW charts in Appendix 1, it is necessary to understand the physical characteristics of the bass clarinet. This has been researched in three stages, analysing single low note tones, comparing the lowest note of the bass clarinet to the lowest note of the bassoon and finally using technology to comprehensively analyse the lowest five tones and their overblown variants (Type One multiphonics).

For my research I have used *Audiosculpt* (version 3.1.8) as my main research and analysis tool. *Audiosculpt* is a sound analysis and processing tool that allows the user to analyse sound in spectral content and includes a function to display results via spectrograms. The programme is available through Ircam's FORUM subscription. By inputting recordings of bass clarinet notes and multiphonics as .AIF or .WAV files *Audiosculpt* has allowed the discovery of the following:

- a/ Which frequencies emerge when playing straight single notes on the bass clarinet.
- b/ How multiphonics that are produced by manipulating the embouchure (altering the amount of pressure on the reed) using standard low note fingerings are formed by analysing the strongest frequencies in these chords.
- c/ How the frequencies change when a performer overblows (or plays an overtone) variants based on the harmonic series on the lowest five tones of the instrument.

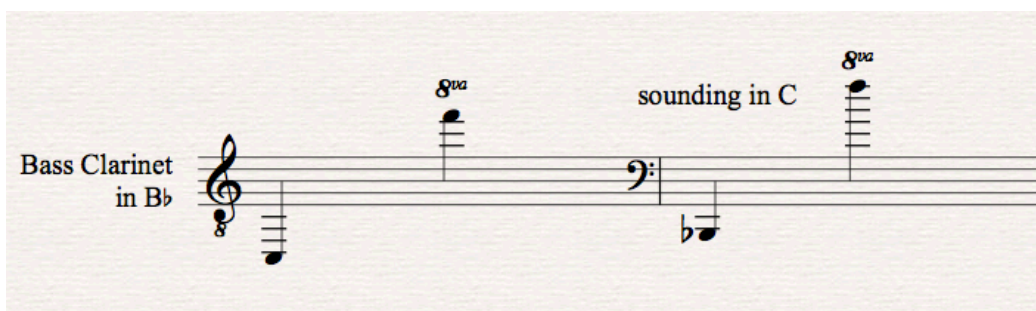
- d/ Which frequencies are the strongest when playing multiphonics based on special fake fingerings (Type Two) on the bass clarinet . This has provided me with an essential tool to aid me in creating accurate new sets of multiphonic charts for the instrument. See chapter four for Type Two multiphonics.

The first phase of research was spent looking at and learning about exactly how the bass clarinet works on a more scientific level. As a performer, one is focused on producing a single note, and the emphasis is very much on how to produce that note with the most appropriate tone colour that suits the player, the audience and the piece being performed. In order to successfully understand and be able to learn fully how the bass clarinet and multiphonics work, however, a performer must realise that a note is not just one pure tone but many frequencies all linked together to create the note being heard. Being aware of the basic science of how a note is formed should influence how a performer thinks and listens, which in turn should help them to understand the whole field of multiphonics.

All of the charts and notations are in the written key of B flat which is the natural key of the instrument. The justification for notating in B flat and not in concert pitch is in order to avoid problems that have occurred with previous multiphonic charts that are notated in the sounding key of C, which has caused immense confusion and inaccuracies for composers in the past. This has resulted in many compositions that have multiphonics that are in the wrong key and do not work as intended.

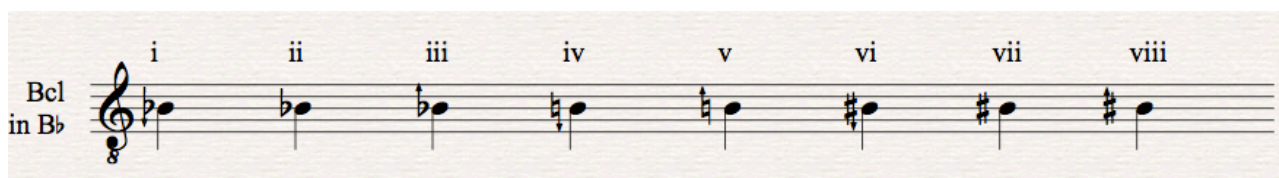
Any written examples will sound an interval of a 9th lower as shown in Fig. 3.1.a

**Figure 3.1.a: Played range of the bass clarinet**



Regarding the notation, quarter tones and eighth tones are notated using arrows to indicate if a note is slightly sharp or slightly flat. Due to differences in reeds, instruments, temperature and embouchures, it was decided dissecting notes into notated quarter and eighth tones may result in inaccuracies and further confusion. Where an important tone in the charts is close to a quarter or eighth tone, there is more precision in the theoretical analysis. Notation symbols for accidentals are explained in Figures. 3.1.b, where i, ii and iii are flat notes, iii and iv are natural notes and vi, vii and viii are sharp notes. An arrow pointing downwards indicates that the note is sounding below pitch and an arrow pointing upwards indicates that the note is sounding above pitch.

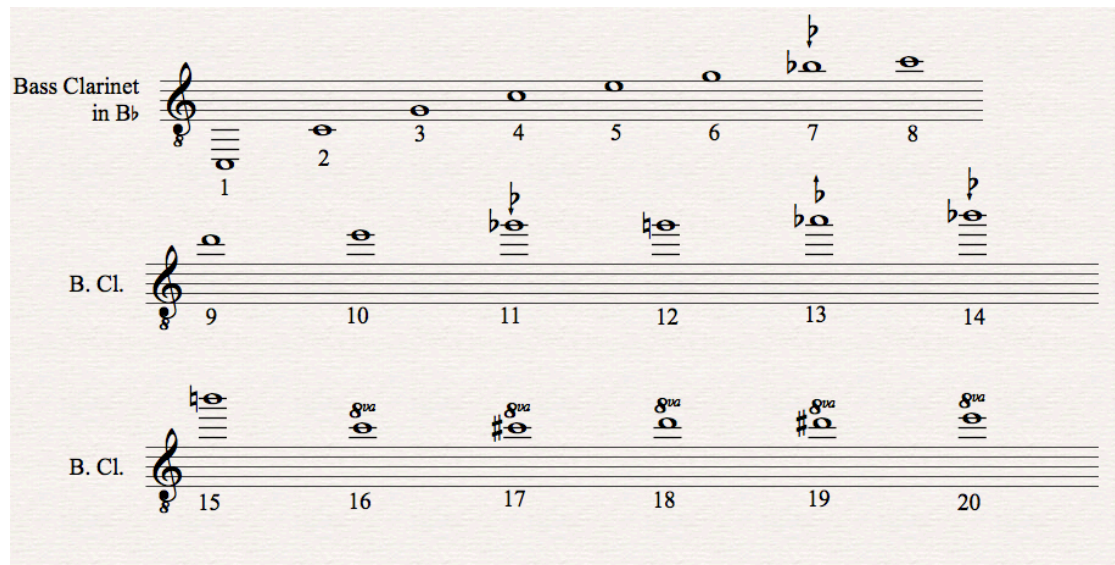
**Figure. 3.1.b: Guide for approximate pitches of quarter and eighth tones**



To understand the physics of the bass clarinet an awareness of the harmonic series is paramount. Figure. 3.2 shows the harmonic series starting on a low C (the lowest tone of the bass clarinet) and covers the played range of the instrument. It is important to notice

that it is normal that the seventh, eleventh and fourteenth partials of the series sound flat and the thirteenth of the series sounds sharp.

**Figure 3.2: The harmonic series**



If a bass clarinetist plays a low C and overblows into the upper registers without adding the register key (the register key is the left-hand thumb key at the back of the instrument that makes the low notes sound an interval of a twelfth higher – this is different to other wind instruments, for which there is an octave leap into the upper register), then in theory, because the instrument is essentially a cylindrical tube closed at one end, the bass clarinet should be able to play only the uneven partials of the harmonic series. This should contrast with other woodwind instruments such as the flute (cylindrical pipe open at both ends) and the oboe and bassoon (tapered conical pipes closed at one end) which should all be able to play the whole series. The inadequacy of this model is easily seen, however, since it is usual to find that in fact most if not all partials will be present other than the lowest partials – certainly all partials from the seventh up should appear (see Fig. 3.3.i). The tuning may vary by a small amount due to factors such as embouchure, reed strength and the player’s ability to play the higher partials. There is no reference to this theory being

tested or questioned in the two main bass clarinet technique books by Henri Bok<sup>61</sup> or Harry Sparnaay<sup>62</sup>; however Michael E. Richards talks about the conflict between the theory and the practical testing of the clarinet in his research '*The Clarinet of the Twenty-First Century*<sup>63</sup>', in which the results that occur on the clarinet also occur on the bass clarinet. '*The Physics of Musical Sound*', by Dr John Askill<sup>64</sup>, discusses this matter but has no answers as to why this happens. Other acousticians, such as John Backus, have researched this area on clarinet (not bass clarinet), and his article '*Resonance Frequencies of the Clarinet*<sup>65</sup> offers explanations such as that factors such as the flared bell, the shape of the mouthpiece cavity and the covered tone holes could all affect the acoustics and help to challenge this theory.

To fully understand the character of the bass clarinet and its acoustic nature, all players and composers should have some knowledge of the harmonic series and how it relates to the bass clarinet at a basic level. Figures 3.3.a, 3.3.c, 3.3.e and 3.3.i help to explain this. The results of my research in this chapter on playing straight low notes and Type One multiphonics (multiphonics on low notes created by manipulating the embouchure) prove that the importance of understanding the basics of the harmonic series and how it reacts with the instrument is very important, especially when it comes to using these types of multiphonics as a compositional technique.

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<sup>61</sup> Henri Bok. *New Techniques For Bass Clarinet*. original edition, Paris, Salabert, 1989, special limited edition, self- published. 2004.

<sup>62</sup> Harry Sparnaay. *The Bass Clarinet: A Personal History*. Barcelona, Periferia Music. 2011

<sup>63</sup> E Michael Richards. *The Clarinet of the Twenty First Century*. [www.userpages.umbc.edu/~emrich/clarinet21.html](http://www.userpages.umbc.edu/~emrich/clarinet21.html) 1990-2000 23 August 2013

<sup>64</sup> Dr. John Askill. *The Physics of Musical Sound*, D. Van Nostrand Company 1979, [http://fiziks.net/physics\\_music\\_text.htm](http://fiziks.net/physics_music_text.htm). 23 August 2013. Chapter 7.

<sup>65</sup> *Acoustical Society of America Journal*. Volume 43, Issue 6, 1968 (pp. 1272-1281).

To help further understand the nature of the bass clarinet, there is a comparison in the figures that follow of the lowest written note C (sounding a concert pitch B flat) on the bass clarinet and the lowest played B flat on the bassoon (which is the same note). Using *Audiosculpt* to analyse and display the frequencies clearly shows that the spectral palette of the bass clarinet is very different to the bassoon – again this is why the bass clarinet sounds and works as it does. I have used preset bass clarinet settings for the bass clarinet analysis and preset bassoon settings for the bassoon analysis. Each spectrogram was viewed at FFT window size of 8192 samples and a window step at 8x, i.e. the overlap or 'hop' size was 1024 samples. All recordings in the studio and, later, a church (for final CD quality recordings) were recorded using a close microphone configuration. In addition to sonogram charts (for example Fig. 3.3.a), a Partial Tracking graph is also displayed (see, for example Fig. 3.3.e). This is where partials can be viewed using clear lines, according to the variations in their amplitude. Both readings in the Partial Tracking frequency were set to an amplitude threshold of -40db and the window box for maximum number of partials was set at 15.

Each multiphonic was recorded for approximately 5 to 8 seconds and the section of each multiphonic used for analysis or shown in diagrams in this thesis is the section in which the frequencies in each multiphonic have 'settled' and become at their most stable.

I have used the resource [http://omf.paris-sorbonne.fr/IMG/pdf/chart\\_pitch\\_1.pdf](http://omf.paris-sorbonne.fr/IMG/pdf/chart_pitch_1.pdf)<sup>66</sup> for transferring the *Audiosculpt* data into pitch note frequency. A is tuned at 440 Hz. My notation is in the written Key of B-Flat, but I have made the decision to keep any Hz readings in the sounding key of C.

The analysis of the lowest tones on the bass clarinet and bassoon are compared via analysis using the following charts, graphs and notated results:

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<sup>66</sup> Marc Battier. *MIDI Pitch–note–frequency*, 1996. [http://omf.paris-sorbonne.fr/IMG/pdf/chart\\_pitch\\_1.pdf](http://omf.paris-sorbonne.fr/IMG/pdf/chart_pitch_1.pdf). 17 September 2014.

Fig. 3.3.a shows the complete spectral analysis of the bass clarinet's lowest tone (played low C) which is concert B flat 1.

Fig. 3.3.b shows the complete spectral analysis of the bassoon's lowest tone, which is a played B flat/low A sharp 1.

Fig. 3.3.c shows a close-up spectrogram of the bass clarinet's low C from 0Hz to 2000Hz

Fig. 3.3.d shows a close-up spectrogram of the bassoon's low B flat from 0Hz to 2000Hz

Fig. 3.3.e shows a full partial analysis of a bass clarinet's low C

Fig. 3.3.f shows a full partial analysis of a bassoon's low B flat.

Fig. 3.3.g shows a close-up spectrogram of the bass clarinet's low C from 0Hz to 2000Hz

Fig. 3.3.h shows a close-up spectrogram of the bassoon's low B flat from 0Hz to 2000Hz

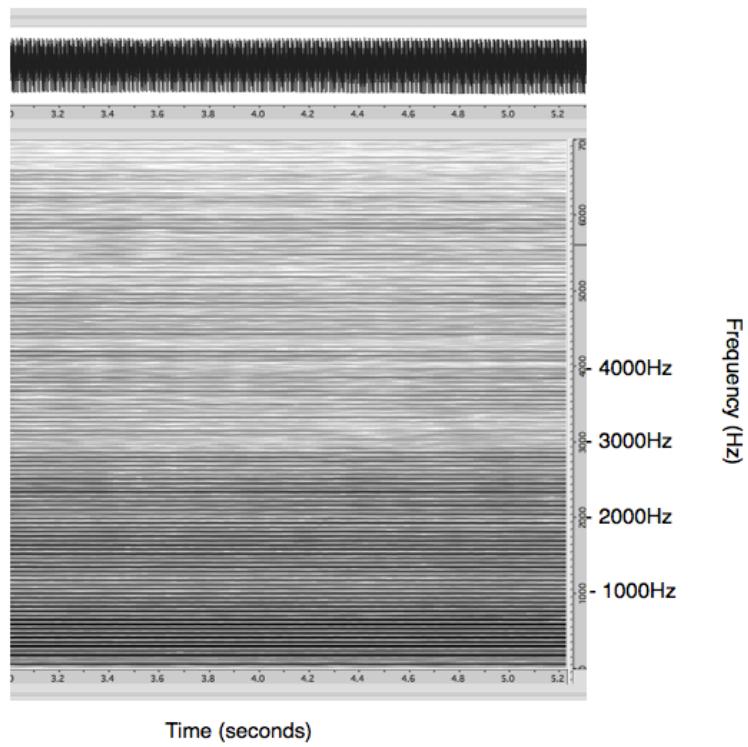
Fig. 3.3.i and j shows the most prominent partials on the bass clarinet's low C (sounding an interval of a 9th lower than written).

Fig. 3.3.k shows the most prominent partials on the bassoon's low B flat

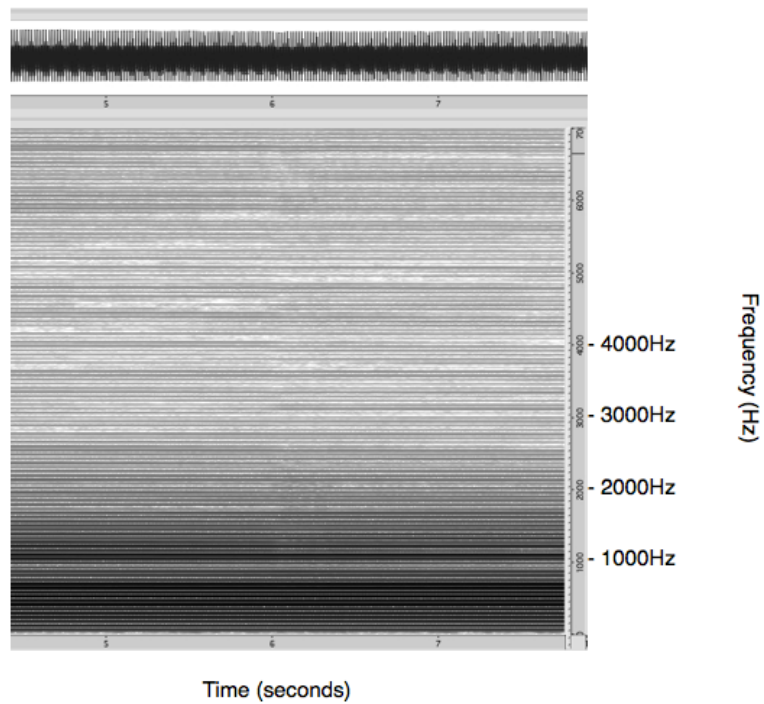
Audio samples for this chapter can be found on CD1, which is a data CD. See Appendix 2 for further details about CD1 and CD2.



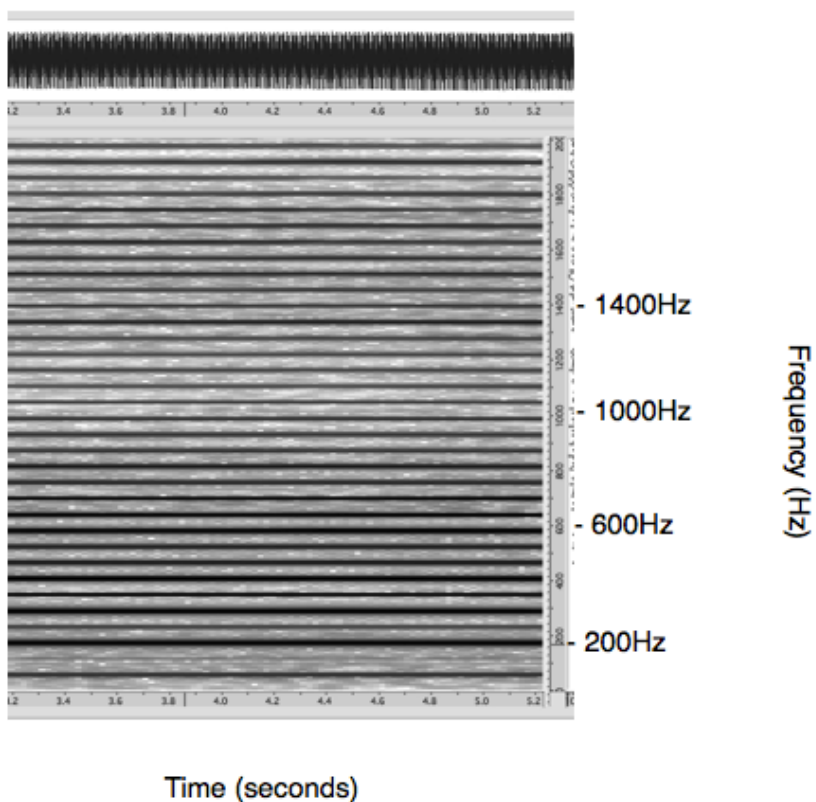
**Figure 3.3.a: Complete spectral analysis of a bass clarinet's low C**



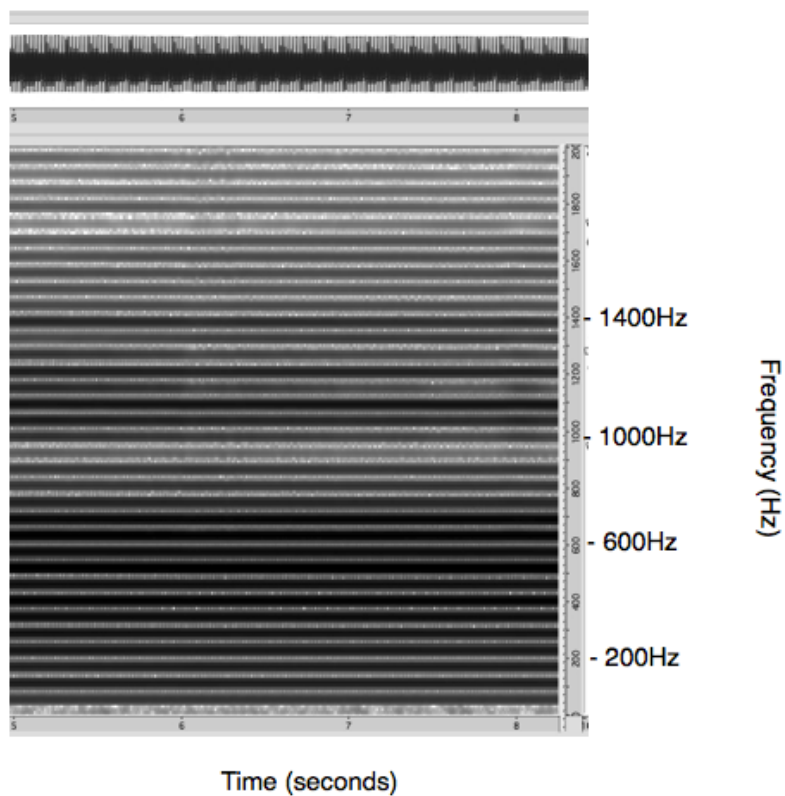
**Figure 3.3.b: Complete spectral analysis of a bassoon's low B flat**



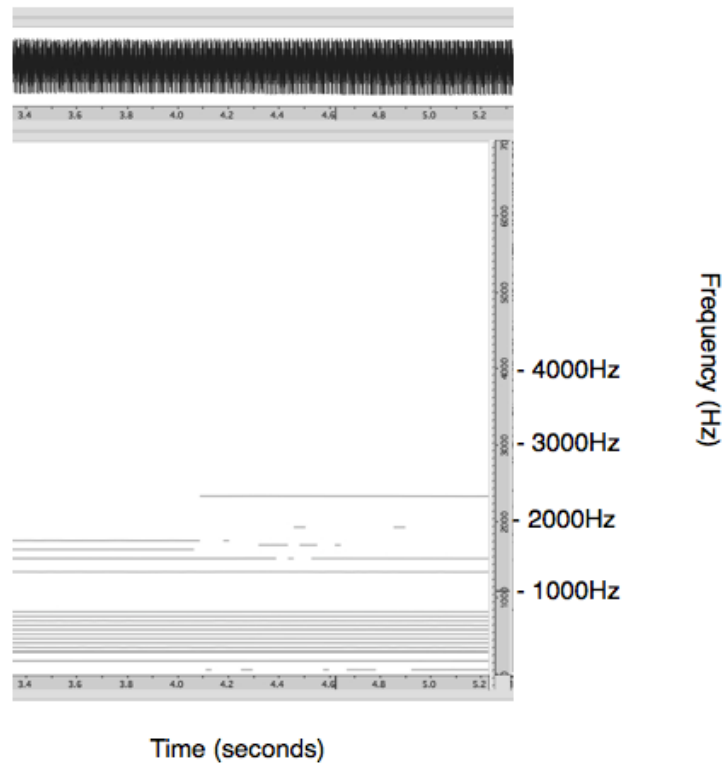
**Figure 3.3.c: Close-up spectrogram of the bass clarinet's low C from 0Hz to 2000Hz**



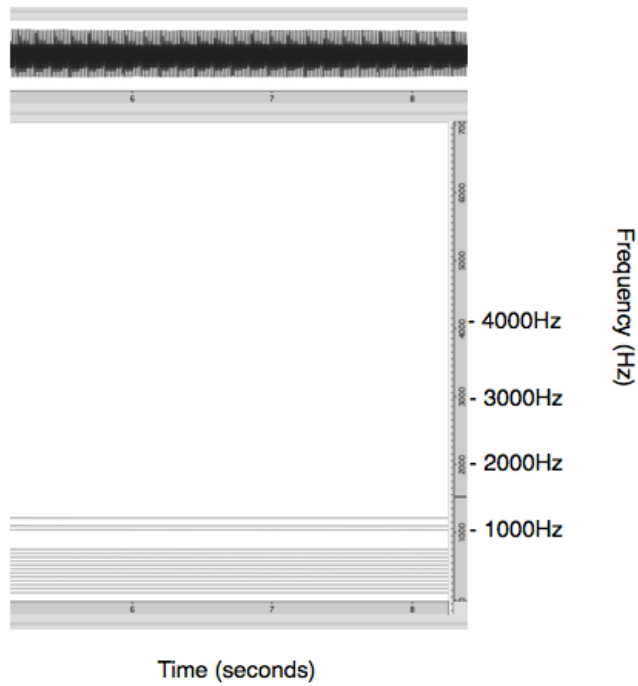
**Figure 3.3.d: Close-up spectrogram of the bassoon's low B flat from 0Hz to 2000Hz**



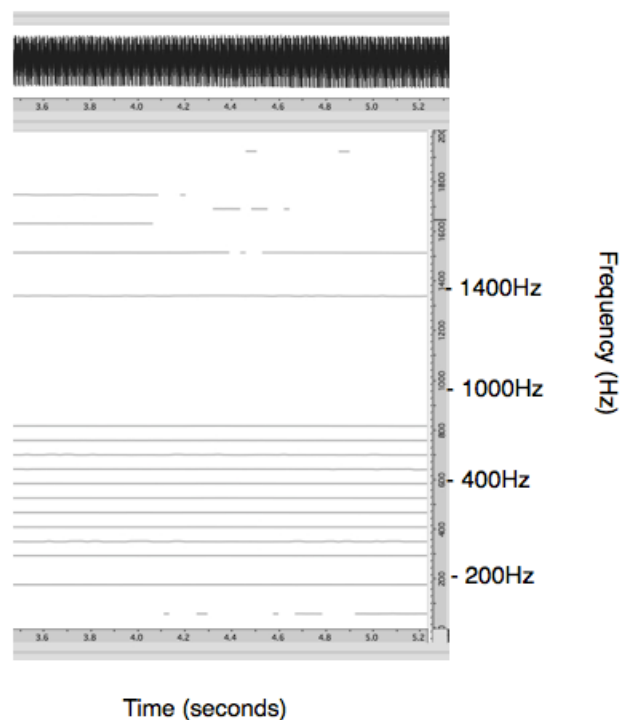
**Figure. 3.3.e: Complete partial analysis of a bass clarinet's low C**



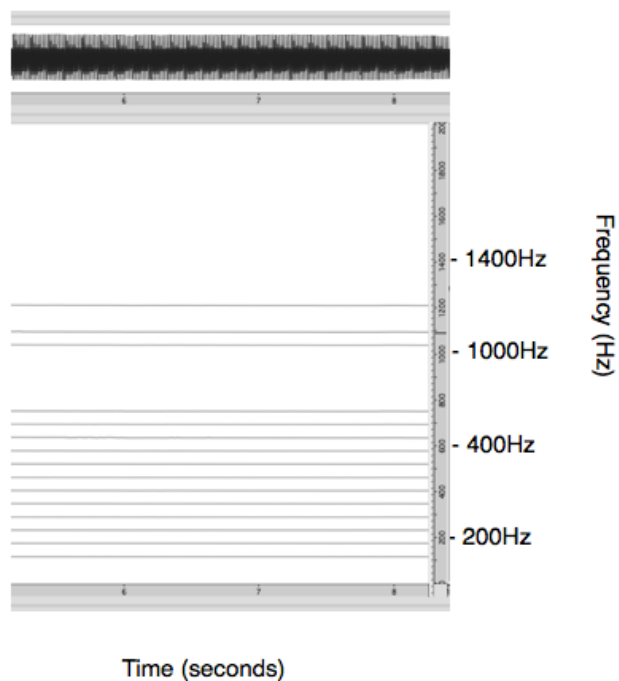
**Figure 3.3.f: Complete partial analysis of a bassoon's low B flat**



**Figure 3.3.g: Close-up spectrogram of the bass clarinet's low C flat from 0Hz to 2000Hz**



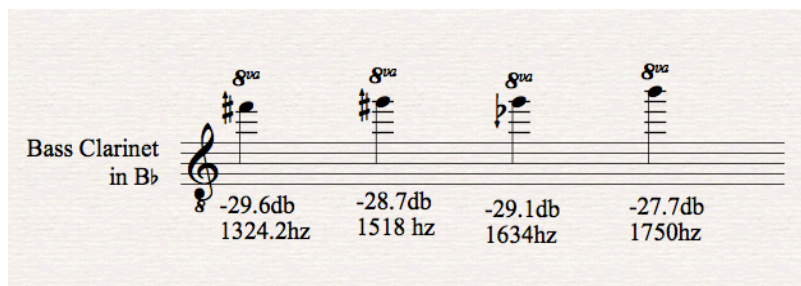
**Figure 3.3.h: Close-up spectrogram of the bassoon's low B flat from 0Hz to 2000Hz**



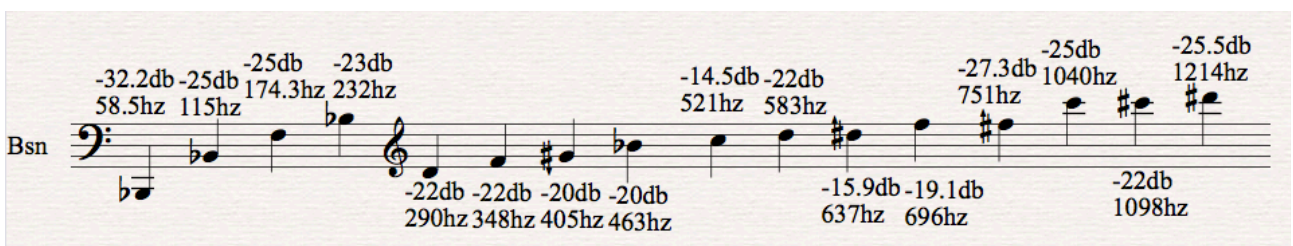
**Figure 3.3.i: The most prominent partials on the bass clarinet's low C (sounding an interval of a 9th lower than written)**



**Figure 3.3.j: The most prominent partials on the bass clarinet's low C above the played range (sounding an interval of a 9th lower than written)**



**Figure. 3.3.k: The most prominent partials on the bassoon's low B flat**



By comparing the lowest notes of the bassoon and the bass clarinet, it can be seen that whilst both instruments share harmonic similarities in the harmonic series, the instruments also have acoustic differences, which can best be seen by visually comparing all of the above Spectrograms and Partial Tracking Analysis displays in Figures 3.3.a to 3.3.h.

The enlarged spectrograms in Figures 3.3.c and 3.3.d are zoomed in to between 0 and 2000Hz (this is above the range of the instruments – the bass clarinet has the widest playable range, with its top playable note being at 1244.51Hz compared to that of a bassoon, which is around 830Hz), which shows that although frequencies can be heard above the playable range of the instruments, the bass clarinet produces much stronger frequencies above the playable range than the bassoon. Figure 3.3.j shows that prominent frequencies are still appearing from the bass clarinet at around 1750Hz; this can be compared to the bassoon (Fig. 3.3.k), which has three prominent out-of-range frequencies from 1040Hz to 1214Hz.

The most important factor is the analysis of the bass clarinet's low C, which proves that its make-up exactly fits the harmonic series; this is also proved when comparing Fig. 3.3.i to the harmonic series chart in Fig. 3.2. The only omissions are the second and fourth partials, which are the C notes one and two octaves about the fundamental. When looked at more closely, it should be observed that although it is the fundamental note, the low C is not the most prominent frequency but is in fact one of the least prominent frequencies. The strongest frequencies are the third, fifth, seventh and eleventh partials. The visual difference shown up in the sonograms and the partials highlighted in the Partial Tracking analysis prove that the bassoon and the bass clarinet have different qualities that make them sound as we hear them and that even though they have the same lowest note and play more or less the same range, the two instruments have very different colours, tone quality and characteristics.

The visual difference shown up in the sonograms and the partials highlighted in the Partial Tracking analysis prove that the bassoon and the bass clarinet have different qualities and features that make them sound as we hear them and that even though they have the same

lowest note and play more or less the same range, the two instruments have very different colours, tone quality and characteristics.

The next section of this chapter is devoted to understanding how Type One multiphonics work and looks at possible problems in notating them which in turn can create conflict between performer and composer.

Manipulating the embouchure by altering the pressure on the reed affects the way in which the reed vibrates and how sound waves move through the instrument, resulting in the ability to build up a series of chords or multiphonics around standard low notes. This is what is called a Type One multiphonic, as opposed to a Type Two multiphonic, which is produced by special fingerings. For each of the lowest five notes on the bass clarinet (low C to low E) I have recorded and analysed five multiphonic variants. *Audiosculpt* has enabled me to analyse how each chord is built up and varies and has also made me question my previous knowledge and thoughts about this type of multiphonic.

By picking out notes in the harmonic series, a player can also overblow and play one of the five variants as a basis for a Type One multiphonic chord. For example, for the multiphonics that are based around a low C, a higher C, E, G, B flat or C can become prominent notes in the multiphonic played. *Audiosculpt* enables this theory to be checked, gives detailed readings of other prominent pitches that feature in each chord and makes it possible to accurately discover how the tuning of chords is affected when the embouchure is manipulated for these chords. It has therefore enabled me to produce charts that give important and accurate readings for this type of multiphonic for the first time.

By manipulating the embouchure when playing a low note using a standard fingering, a variety of different chords that are based around the harmonic series sound. Below is the analysis of five different variants using *Audiosculpt* on low notes C - G. This analysis helps

to explain and understand how this type of multiphonic works on a bass clarinet before undertaking the analysis of Type Two multiphonics using fake fingerings. As the different frequencies are present at different audible levels, the decision was taken to keep practical analysis where possible to 0db to -20db, which are the loudest frequencies. The results of the theoretical analysis have been limited to adding frequencies of -20 to -40db to the practical results.

Certain schools that teach solo bass clarinet advise practising Type One multiphonics around the harmonic series; this is advocated at the Rotterdam Conservatoire in the Netherlands, where I studied solo bass clarinet between 2001 and 2003. I have questioned a number of bass clarinetists from different countries and educational backgrounds, and all but one has said that the harmonic series features strongly in how they think about this type of multiphonic. In chapter three, Henri Bok spoke of how his understanding of the overtone series and therefore Type One multiphonics helped him to discover and start to catalogue Type Two multiphonic fingerings.

Bob Hoit, a bass clarinetist who studied in Rotterdam and now lives and works in Mexico says:

‘ I do think about the harmonic series when I play Type One multiphonics. Until recently I just thought of the harmonics as one, two, three, four, five and would practice chromatically scales with Type One multiphonics. I just concentrated on making the same intervals off each fundamental.<sup>67</sup>’

Eric Mandat, a player in the USA and Professor at Southern Illinois University, and Alex Sramek, a player in Los Angeles, USA, also commented that they are actively aware of the

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<sup>67</sup> Personal correspondence with Robert Hoit, 25th May 2011.



relationship with the harmonic series and the effects that it has on the successful outcome and practice of Type One multiphonics. Both players gave strong indications that an awareness and understanding of this theory is paramount to being able to successfully start to master and control Type One and therefore Type Two multiphonics.

The comment of Stephan Vermeersch, who is from Belgium, adds weight to the evidence that players from all over the world practise Type One multiphonics as a way of improving their overall technique and understanding of the instrument:

‘Depending on the desired result one can overblow in relation to the harmonic series, it all depends on how one uses the oral cavity and the the vocal tract to get the desired multiphonic. And of course practice, practice, practice<sup>68</sup>’.

Figures 3.4.a, 3.5.a, 3.6.a, 3.7.a and 3.8.a show low C and the harmonic the player aims to play by overblowing the higher note shown. These are also suggested notations for the multiphonics being analysed.

Figures 3.4.b, 3.5.b, 3.6.b, 3.7.b and 3.8.b show the full spectrogram for the multiphonic (using settings as described earlier).

Figures 3.4.c, 3.5.c, 3.6.c, and 3.8.c show the spectrogram within the played range of the bass clarinet (see Fig.1).

Figures 3.4.d, 3.5.d, 3.6.d, 3.7.d and 3.8.d show the partial frequency tracking in the played range of the bass clarinet.

Figures 3.4.e, 3.5.e, 3.6.e, 3.7.e and 3.8.e show the notated theoretical results from the sonograms.

Figures 3.4.f, 3.5.f and 3.6.f show prominent out-of-range frequencies.

Figures 3.4.g, 3.5.g, 3.6.g, 3.7.g and 3.8.g show a practical analysis of the most prominent readings.

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<sup>68</sup> Personal correspondence with Stephen Vermeersch, 29 May 2011.

Fig. 3.4.f, 3.5.f and 3.6.f show prominent out of range frequencies.

Fig. 3.4.g, 3.5.g, 3.6.g, 3.7.g and 3.8.g show a practical analysis of the most prominent readings.

### Low C multiphonic A (variant 1)

Figure 3.4.a: Suggested notation

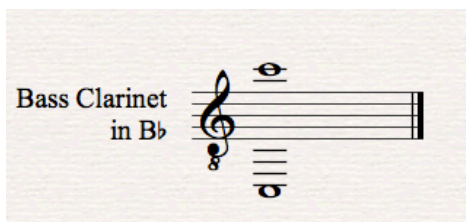
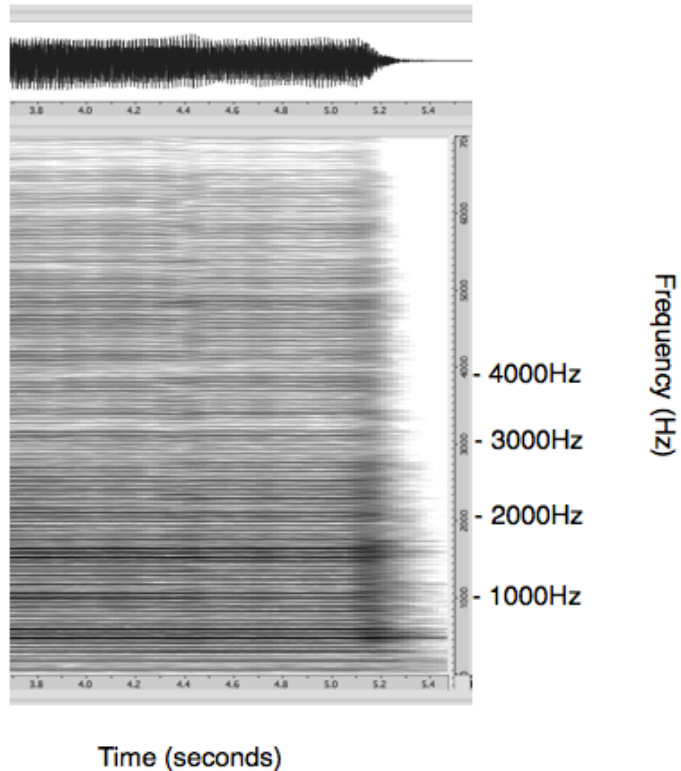
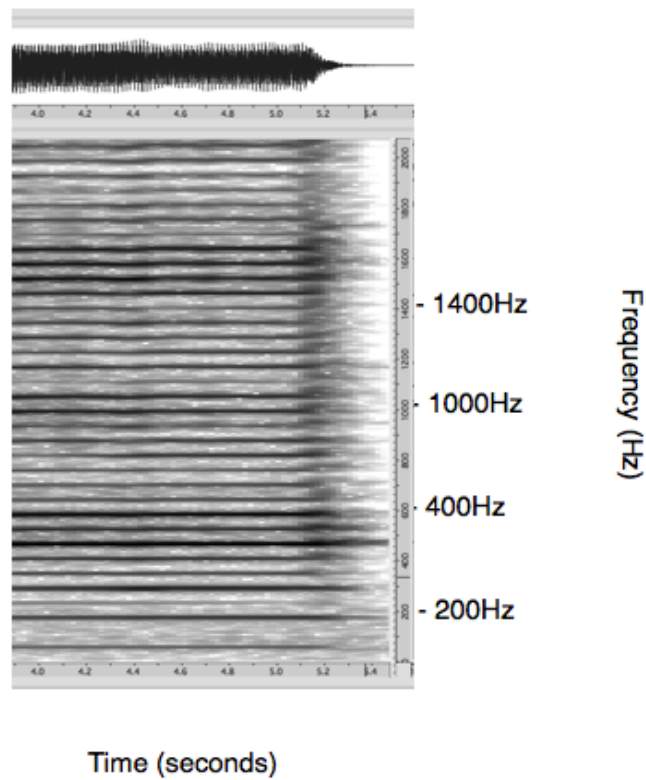


Figure 3.4.b: Full spectrogram of low C multiphonic variant 1



**Figure 3.4.c: Spectrogram within the played range of the bass clarinet for Low C multiphonic variant 1**



**Figure 3.4.d: Partial Tracking of the played range of the bass clarinet for low C multiphonic variant 1**

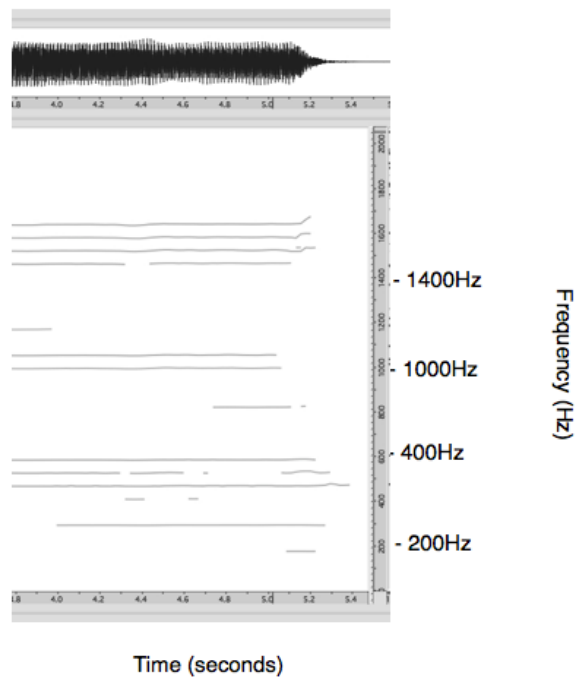


Figure 3.4.e: Notated theoretical results

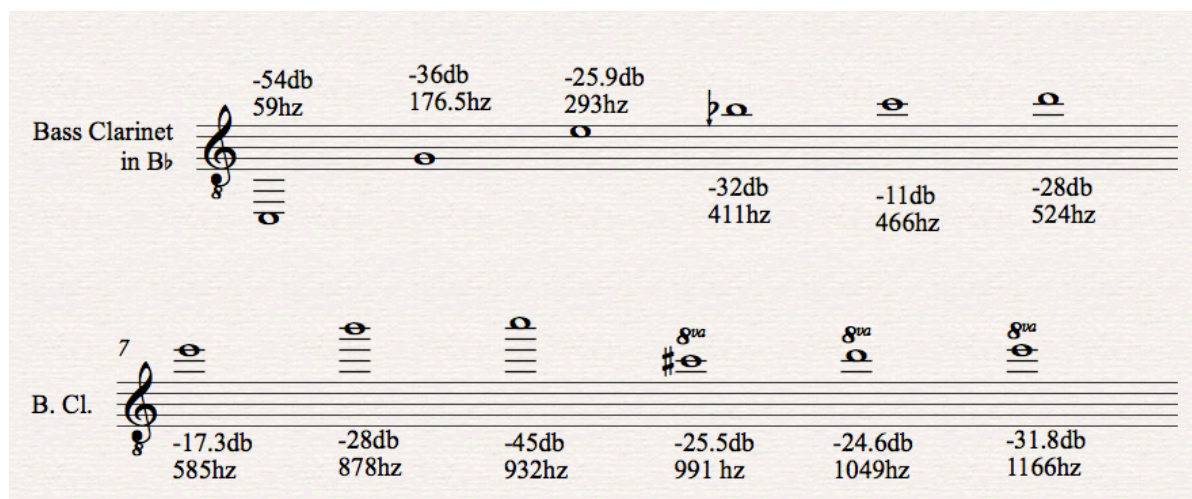
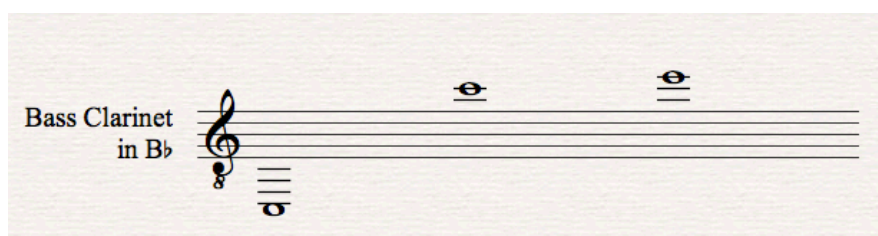


Figure 3.4.f: Prominent frequencies out of usual written range of the instrument



Figure 3.4.g: Practical analysis of the most prominent readings



From this analysis, we can see that some of the most prominent frequencies are out of the playable range of the bass clarinet, as shown in Fig. 3.4.f. Whilst I made a decision to omit these readings from my final theoretical and practical charts, it is important to mention

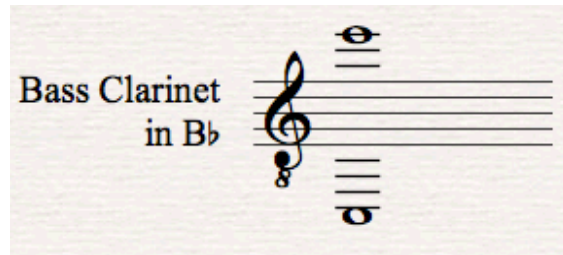
these high frequencies, as they are often important tones in the harmonic series or highlight the interval I am trying to pitch in relation to the variant in question.

I have included the low C in this multiphonic and all other variants as it is the fundamental note and the fingered note. Although it is not prominently heard, it is one of the most important partials in this type of chord as it provides the foundation of the chord when both fingering and playing the multiphonic. In written notation, a suggested chord is just the original two-note note chord (Fig. 3.4.a). To avoid confusion, composers should include in performance notes an explanation saying that although this is a suggested notation, due to the nature of the instrument and factors relating to individual players, extra frequencies will occur.

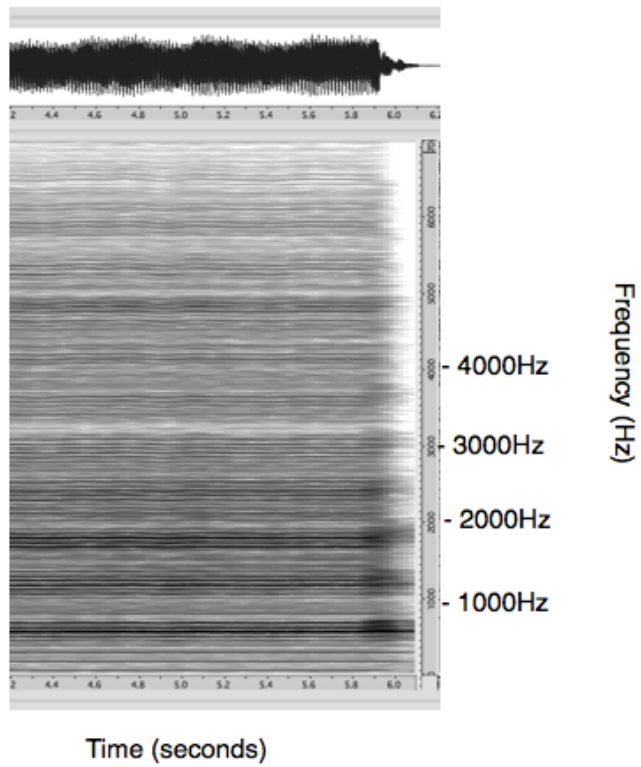
Figure 3.4.e shows that this multiphonic is based around the harmonic series and that the C that is highlighted has the most prominent frequency at -11db. When comparing Figures 3.4.b, 3.4.c and 3.4.d to Figures 3.3.a, 3.3.c and 3.3.e, it is very clear that this variant of the multiphonic produces certain frequencies that are much more prominent than when playing a straight low note. Figures 3.4.b, 3.4.c and 3.4.d show that when playing the multiphonic, the most prominent frequencies are structured into three different range bands. Figures 3.3.i and 3.4.e show the B flat is flat in pitch. Figure 3.4.e also tells us that the low C now becomes one of the least prominent frequencies at a barely audible -54db (as opposed to -30db in Fig. 3.3.i). A final, more practical, consideration of the most prominent readings (0 to -20) would be Fig. 3.4.g

**Low C multiphonic B (variant 2)**

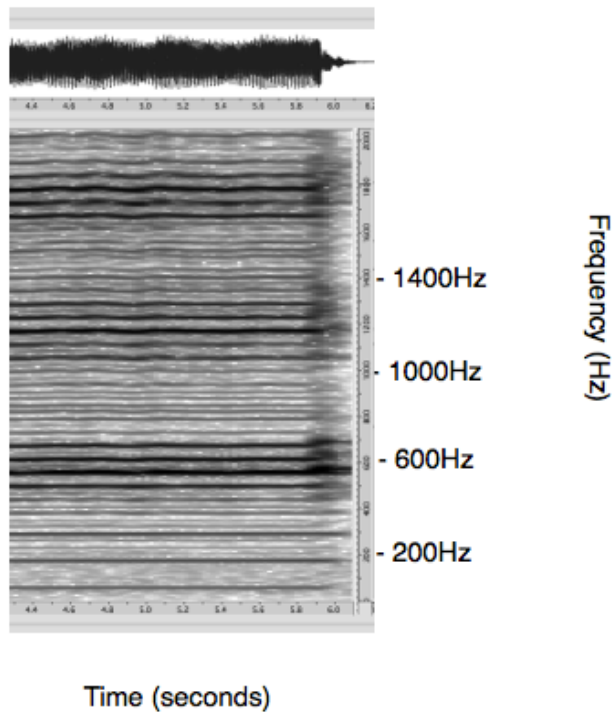
**Figure 3.5.a: Suggested notation**



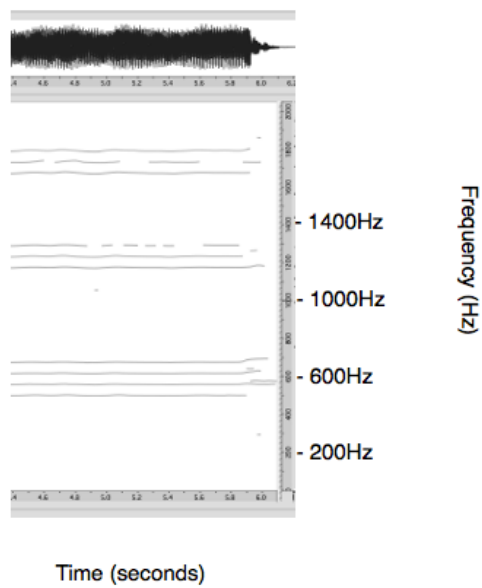
**Figure 3.5.b: Full spectrogram of low C multiphonic variant 2**



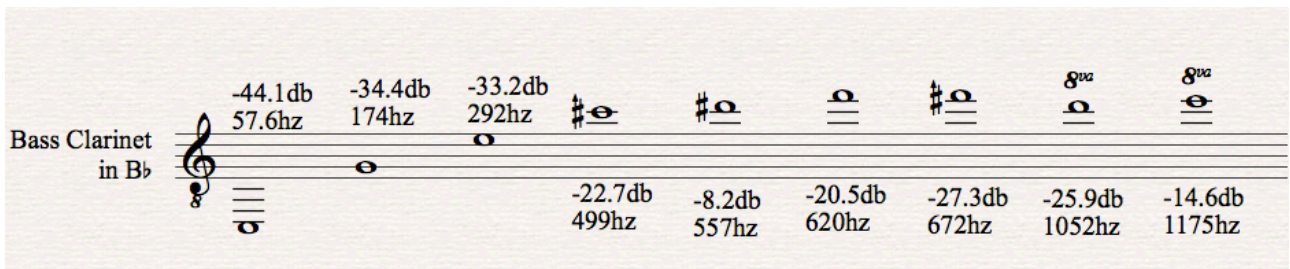
**Figure 3.5.c: Spectrogram of the played range of the bass clarinet for low C multiphonic variant 2**



**Figure 3.5.d: Partial Tracking of the played range of the bass clarinet for low C multiphonic variant 2**



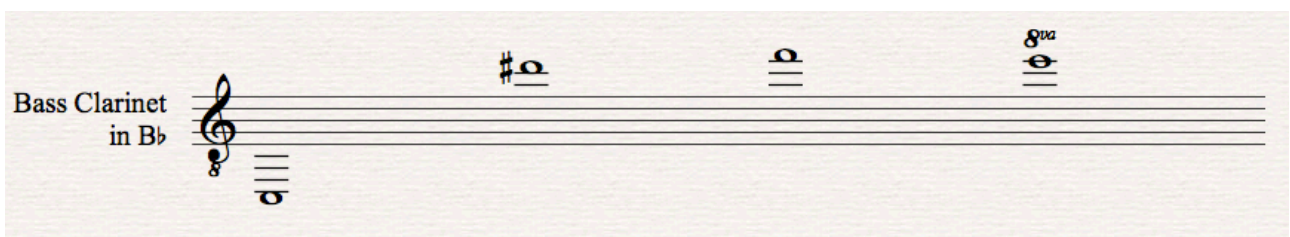
**Figure 3.5.e: Notated theoretical results**



**Figure 3.5.f: Prominent frequencies out of usual written range of the instrument**



**Figure 3.5.g: Practical analysis of the most prominent readings**



For this multiphonic, low C is fingered and an E three octaves higher is overblown by manipulating the embouchure (Fig. 3.5.a). Figure 3.5.c clearly shows how the three bands of prominent partials are higher in range than in Fig. 3.4.c. Despite aiming to play an E three octaves higher than the low C, Fig. 3.5.e shows that this E is not a prominent frequency – the most prominent frequency is the D sharp next to it and the F after that. The pitched E appears prominently a full octave higher.



Prominent out-of-range frequencies for this multiphonic are shown in Fig. 3.5.f. A practical analysis of the most prominent readings results in the chord shown in Fig. 3.5.g. Figure 3.5.a also shows a suggested notation for this multiphonic.

### Low C multiphonic C (variant 3)

Figure 3.6.a: Suggested notation

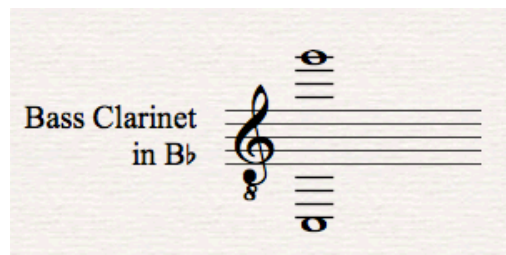
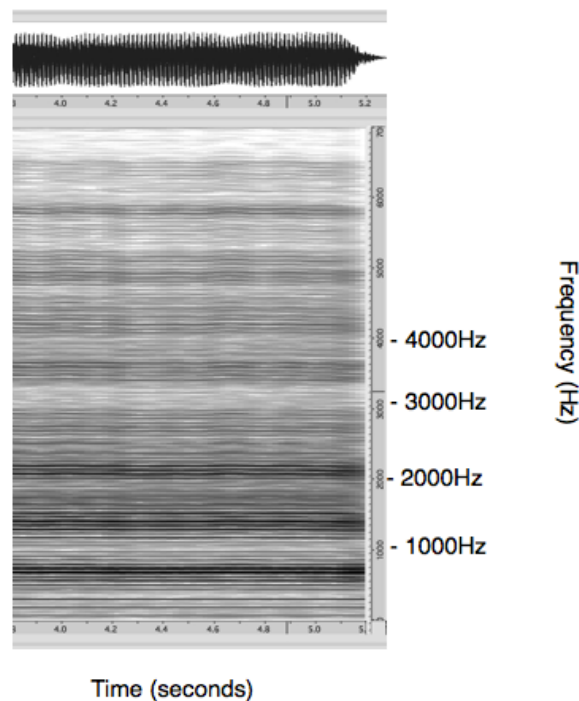
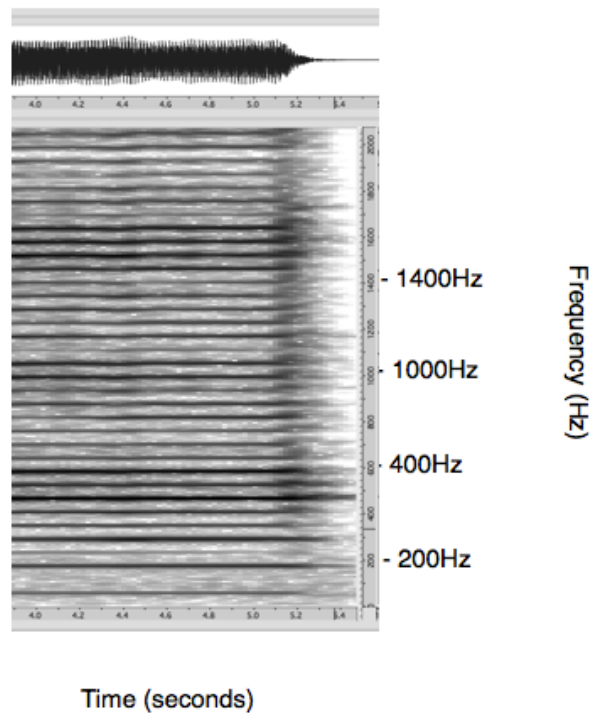


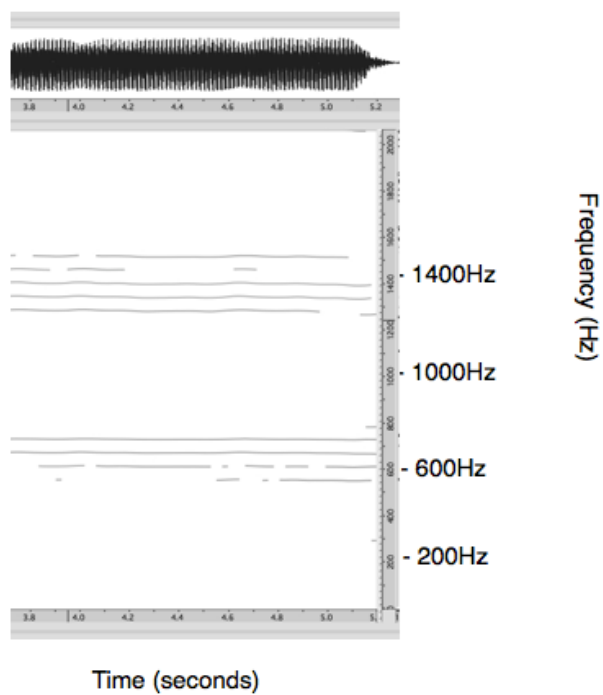
Figure 3.6.b: Full spectrogram of low C multiphonic variant 3



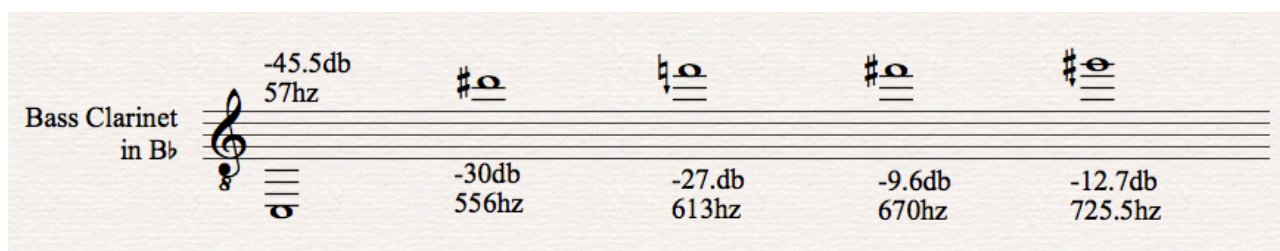
**Figure 3.6.c: Spectrogram of the played range of the bass clarinet for low C multiphonic variant 3**



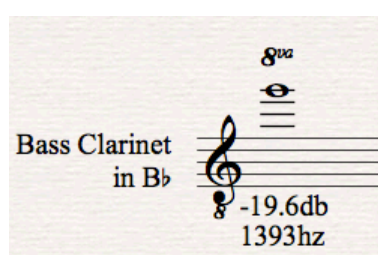
**Figure 3.6.d: Partial Tracking of the played range of the bass clarinet for low C multiphonic variant 3**



**Figure 3.6.e: Notated theoretical results**



**Figure 3.6.f: Prominent frequencies out of usual written range of the instrument**



**Figure 3.6.g: Practical analysis of the most prominent readings**



For this multiphonic, the low C is fingered and a G three octaves higher is overblown.

Figure 3.6.a is a suggested notation. As with low C multiphonic variant B, the highlighted note, this time G in Fig. 3.6.a, does not feature; however, this time it doesn't occur at all prominently as a frequency in the played range of the bass clarinet.

The F sharp is the most prominent frequency, together with the slightly flat G sharp.

The only frequency that is out of playable range, however, that is prominent at 0 to -20db is the G (Fig. 3.6.f).

When looking at Fig. 3.6.c and Fig. 3.6.d, we can see that there are now only two bands of more prominent frequencies, as the third band (which is clear in Fig. 3.6.b) has moved beyond the playable range. A practical analysis is shown in Fig. 3.6.g.

### Low C multiphonic D (variant 4)

Figure 3.7.a: Suggested notation

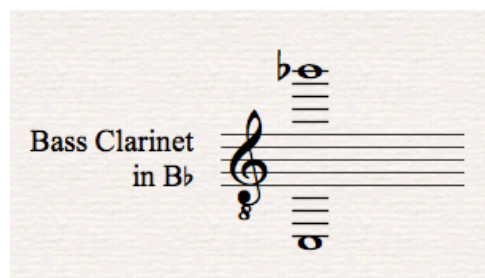
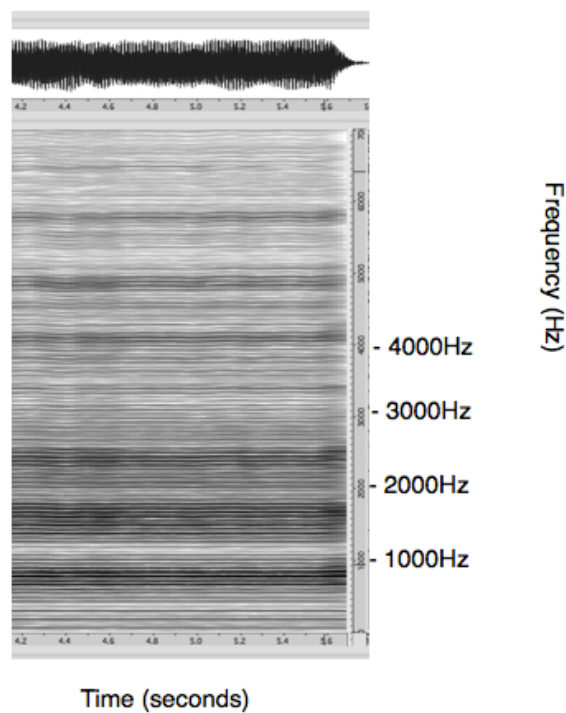
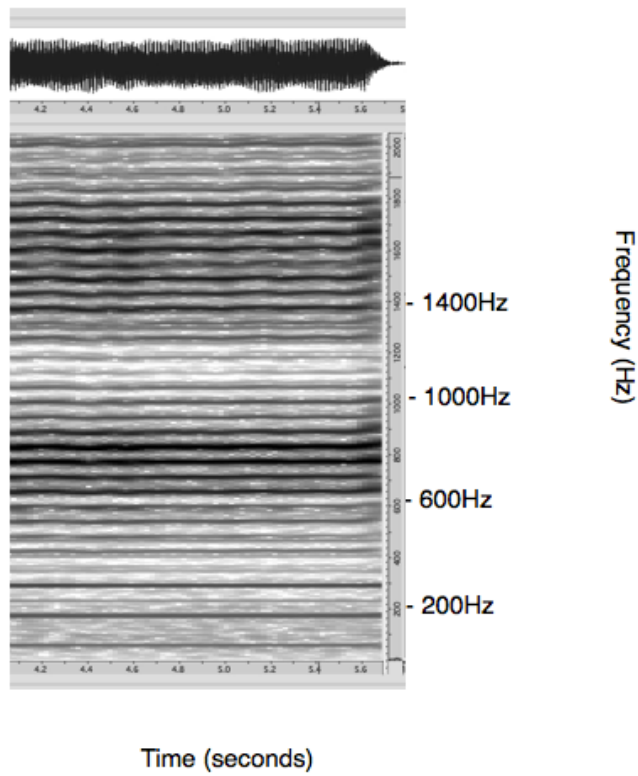


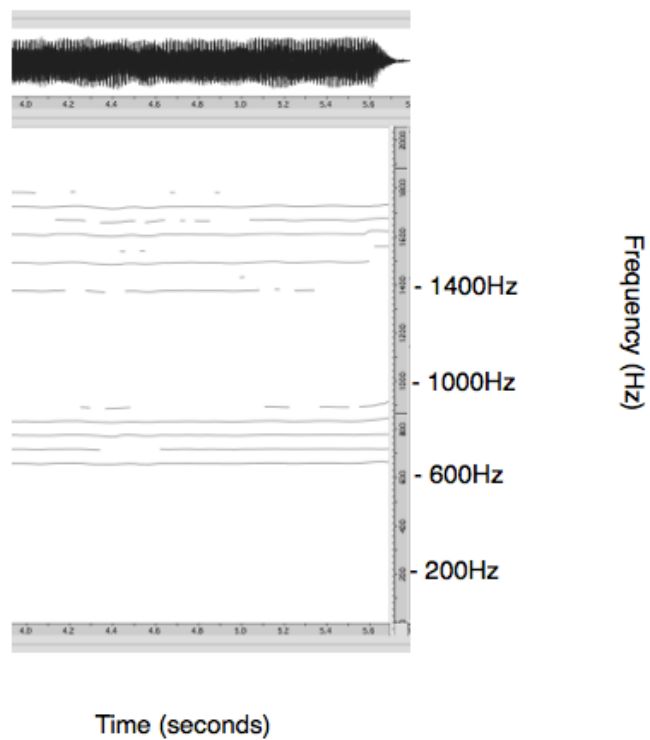
Figure 3.7.b: Full spectrogram of Low C multiphonic (variant 4)



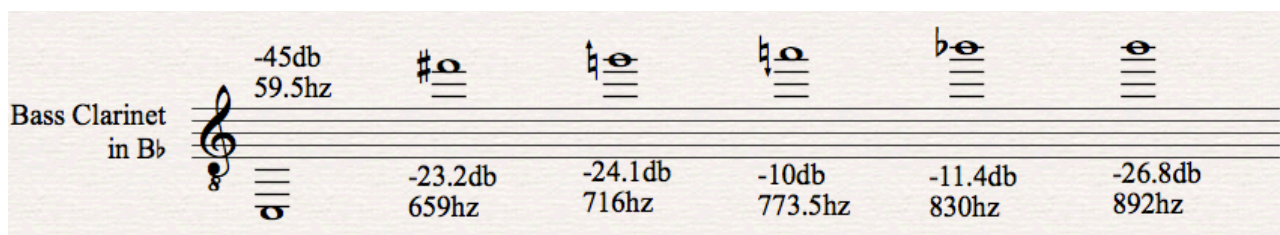
**Figure 3.7.c: Spectrogram of the played range of the bass clarinet for low C multiphonic variant 4**



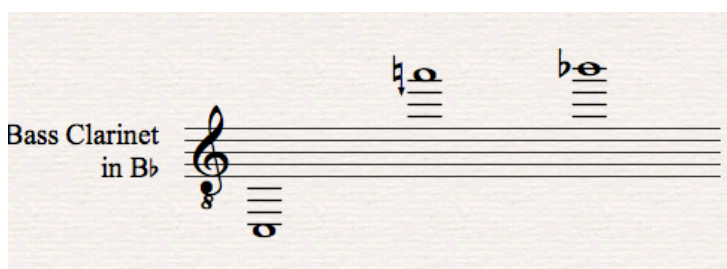
**Figure 3.7.d: Partial Tracking of the played range of the bass clarinet for low C multiphonic variant 4**



**Figure 3.7.e: Notated theoretical results**



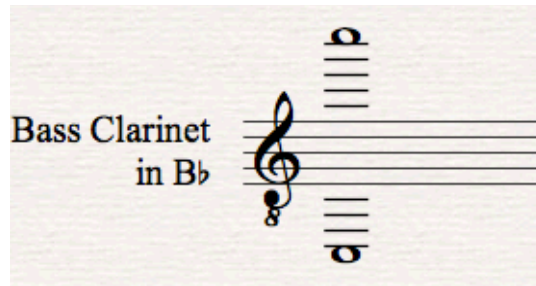
**Figure 3.7.g: Practical analysis of the most prominent readings**



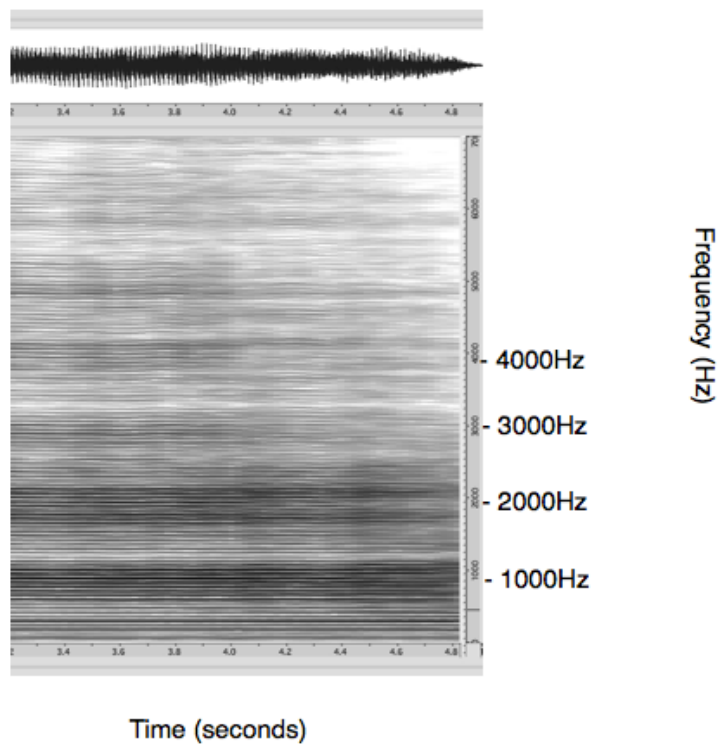
For this multiphonic, low C is fingered and a B flat three octaves higher is overblown. Figure 3.7.a is a suggested notation. Figure 3.7.e shows the pitched B flat as one of the main prominent frequencies. The strongest frequency is the A, which sounds an eighth tone flat in pitch. Figures 3.7.c and 3.7.d show that again the third band of prominent frequencies is above playable range; however, when analysed, none of these out-of-range frequencies are strong enough to be mentioned so there is no Fig. 3.7.f. A practical analysis is shown in Fig. 3.7.g

**Low C multiphonic E (variant 5)**

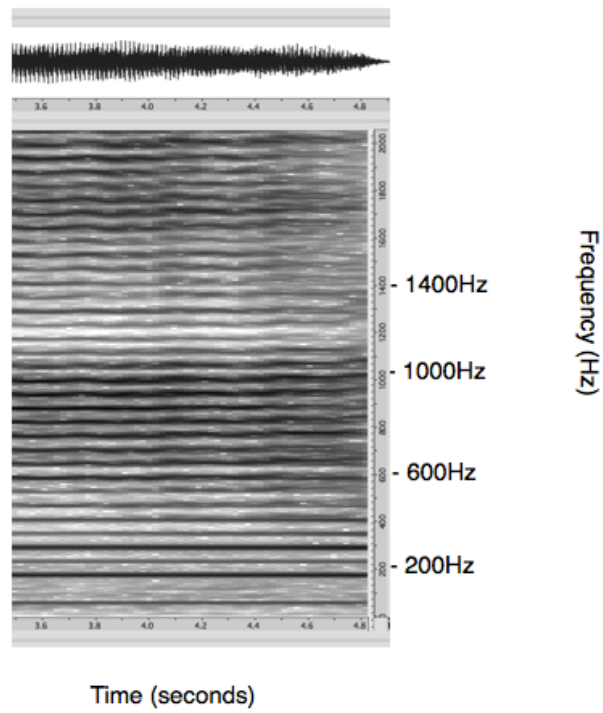
**Figure 3.8.a: Suggested notation**



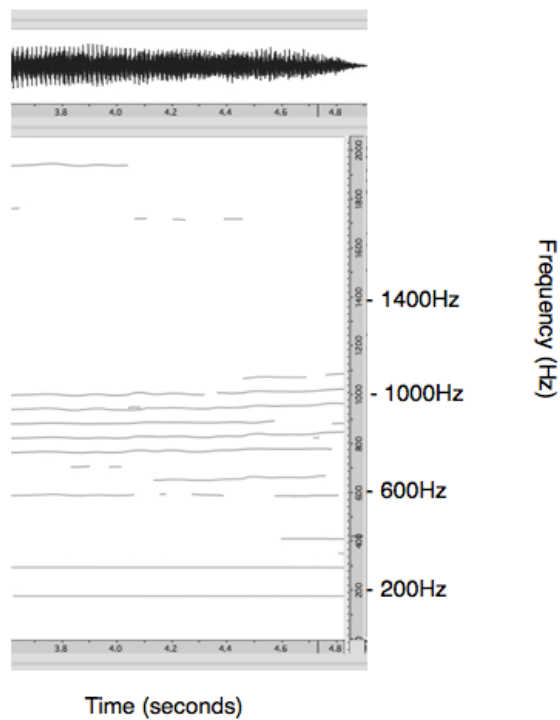
**Figure 3.8.b: Full spectrogram of low C multiphonic variant 5**



**Figure 3.8.c: spectrogram of the played range of the bass clarinet for low C multiphonic variant 5**

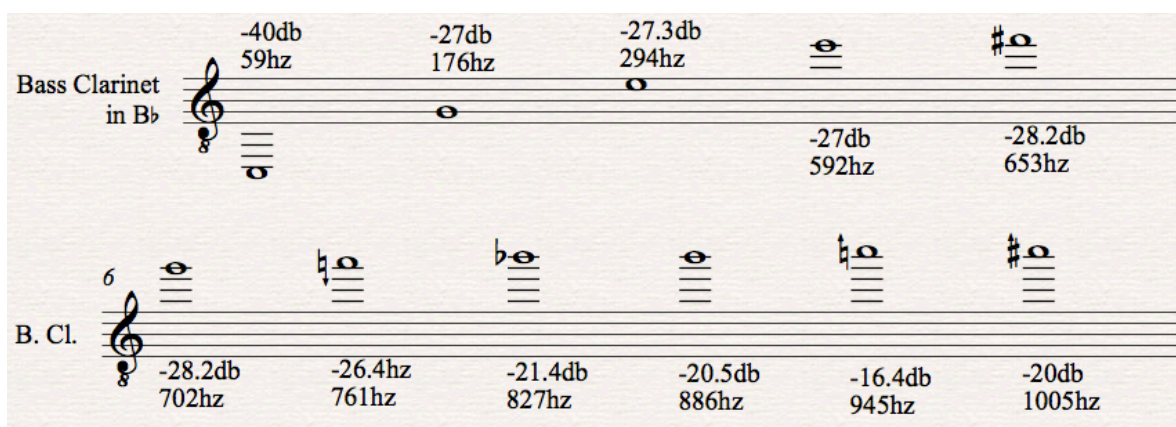


**Figure 3.8.d: Partial Tracking of the played range of the bass clarinet for low C multiphonic variant 5**

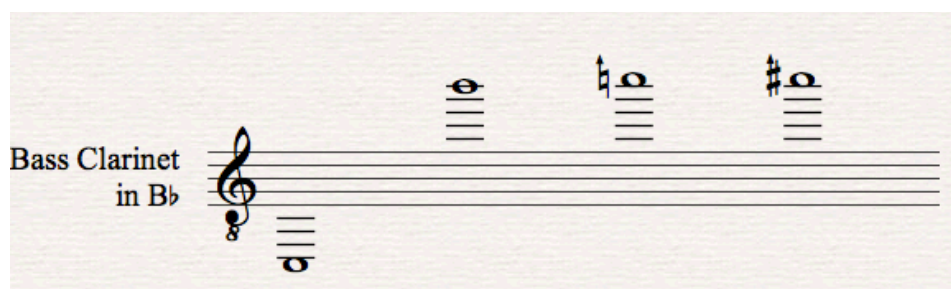




**Figure 3.8.e: Notated theoretical results**



**Figure 3.8.g: Practical analysis of the most prominent readings**



For this multiphonic, low C is fingered and C four octaves higher is overblown. Figure 3.8a is a suggested notation. Fig. 3.8.e shows the high C; this is the most dominant frequency, sounding an eighth tone sharp. We can see from Fig. 3.8.c and Fig. 3.8.d that again the third band of prominent frequencies is out of playable range, and when analysed none of these is strong enough to be mentioned so there is no Fig. 3.8.f. A practical analysis is shown in Fig. 3.8.g

The five analyses and charts above show that when manipulating the embouchure between these multiphonics, the tuning of the low C can vary up to an eighth tone in either direction. This can be compared in Figs. 3.4.e, 3.5.e, 3.6.e, 3.7.e and 3.8.e. I took great

care to ensure that each variant I recorded was tuned to A=440, and the majority of frequencies keep very close to pitch. The most important factor is that only the low C multiphonic A (the first variant) follows the route of the harmonic series. When comparing Fig. 3.e to the harmonic series chart in Fig. 3.2, it should be noted that all the strong partials are in the harmonic series. When we look at and compare Figs. 3.5.e, 3.6.e, 3.7.e and 3.8.e to the harmonic series in Fig. 3.2, we can see that the frequencies produced in these multiphonic variants start to move away from the harmonic series in such a way that for some variants it is hard to relate to a low C other than the fundamental low C, which, as discussed earlier, becomes one of the less dominant frequencies in any case.

One can conclude that embouchure tightening and relaxing whilst pitching the different variants can sometimes result in certain notes being forced to sound slightly out of pitch. This is also seen in Fig. 3.8.e (the top notes are sharp) where the embouchure is tighter than when playing lower note variants.

The results of this analysis should be observed by performers, as it is vital that a player can understand and play these types of multiphonics. The results also suggest that it is very difficult to accurately notate this type of multiphonic. For example, for multiphonic B variant 2, Fig. 3.5a, a player expects to be able to play a low C, overblow and make an E three octaves higher sound. My research has shown me, however, that this E simply isn't present in the chord. It could be that this multiphonic could be notated to look like a chord, as shown in Fig. 3.5g, but this would be very hard and impractical for any player to accurately pitch and play, especially when all previous theories are centred around the multiphonic series. This evidence justifies the need for approximation of written pitches in the advisory notations.

Below are the results for the multiphonics from low C sharp to E. As with the low C multiphonics, there are five variants for each of the notes from C sharp to E. The same settings on Audiosculpt were used to analyse these multiphonics, and the following charts list the harmonic series for the note in question, a suggested notation, a theoretical notation and a practical notation.

Fig. 3.9 shows the Harmonic Series Notation Chart for low C sharp.

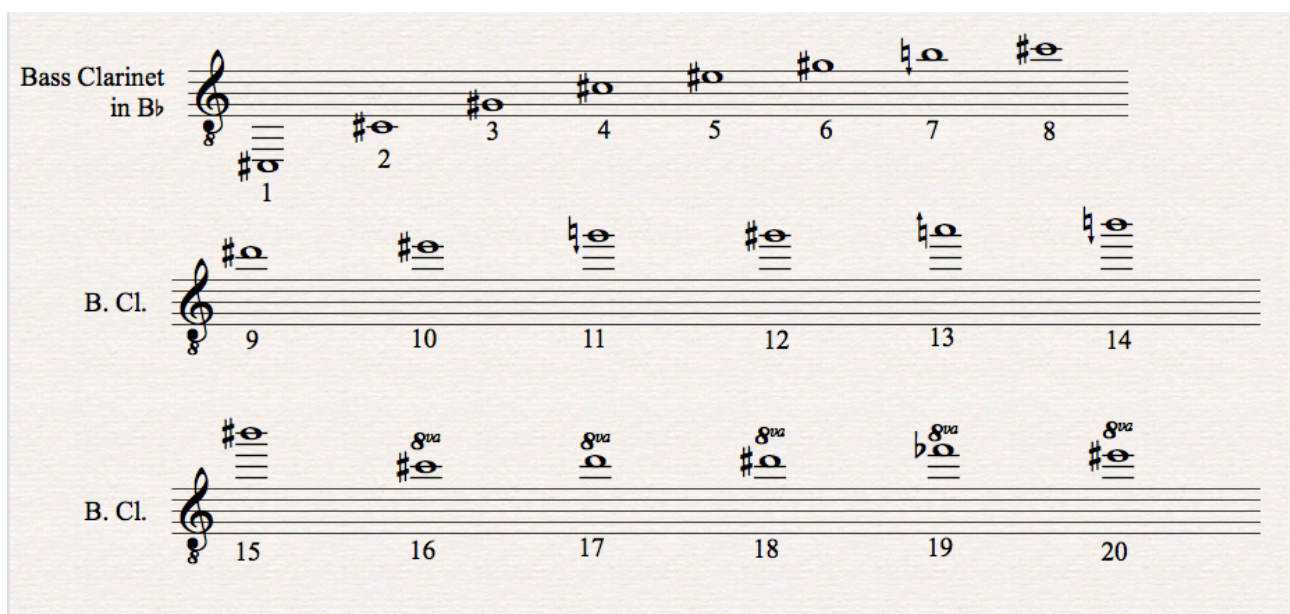
Figs. 3.10.a, 3.11.a, 3.12.a, 3.13.a, 3.14.a and 3.15.a show suggested notation for the multiphonic being analysed.

Figs. 3.10.b, 3.11.b, 3.12.b, 3.13.b, 3.14.b and 3.15.b show the theoretical notations of the most prominent frequencies between 0db and -40db.

Figs. 3.10.c, 3.11.c, 3.12.c, 3.13.c, 3.14.c and 3.15.c show very prominent out-of-range frequencies produced for the multiphonic.

Figs. 3.10.d, 3.11.d, 3.12.d, 3.13.d, 3.14.d and 3.15.d show a more practical notation of only the strongest frequencies that are present in the chord being played.

**Figure 3.9: Low C sharp harmonic series**



## Low C Sharp multiphonic A (variant 1)

Figure 3.10.a: Suggested notation

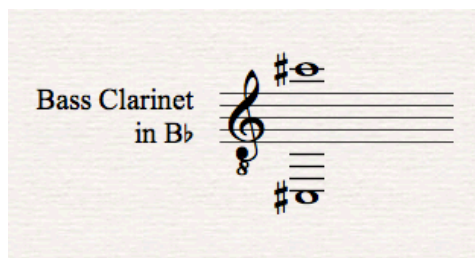


Figure 3.10.b: Notated theoretical results

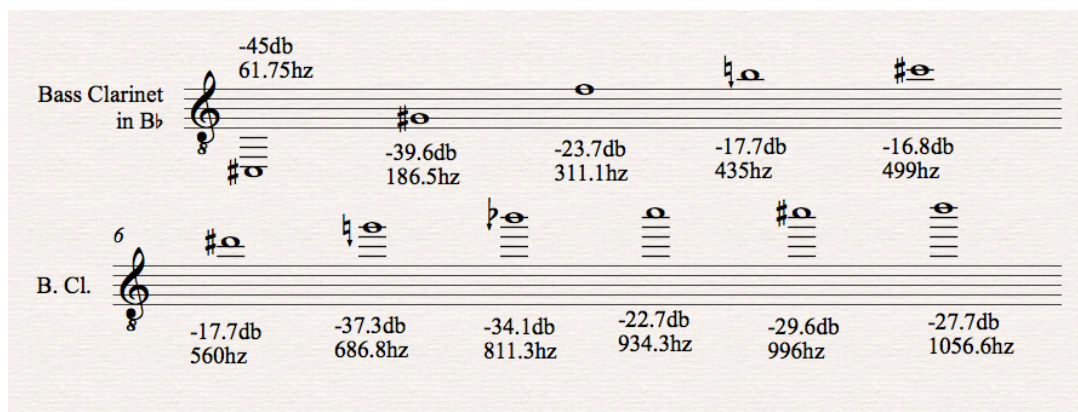
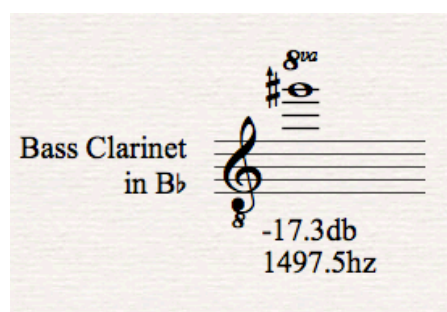
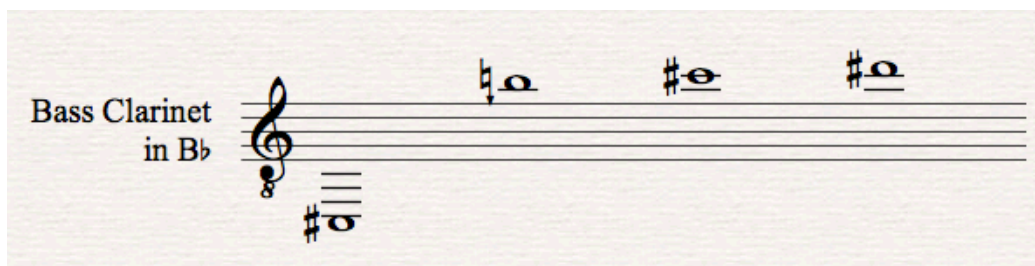


Figure 3.10.c: Prominent frequencies out of usual written range of the instrument



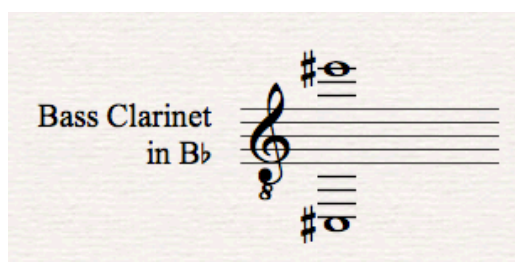
**Figure 3.10.d: Practical analysis of the most prominent readings**



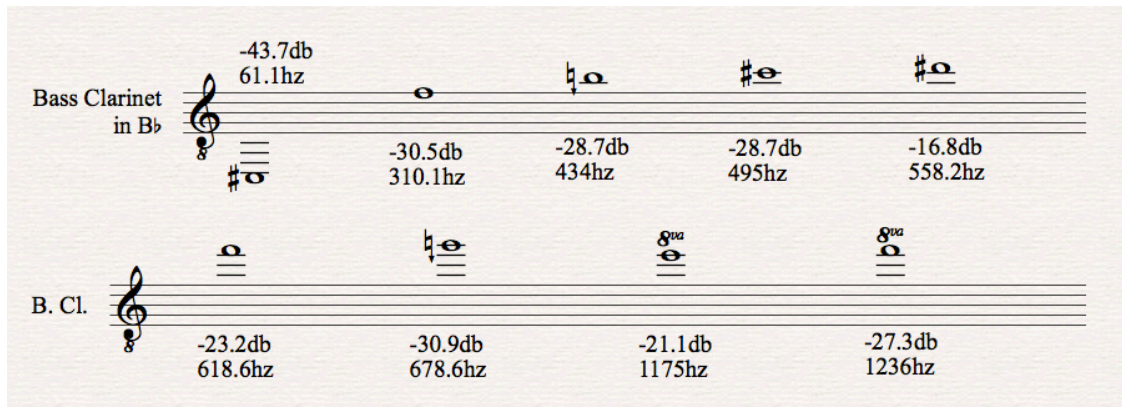
For this multiphonic variant A on a fingered low C sharp, a C sharp three octaves higher is overblown as shown in Fig. 3.10.a. Figure 3.10.b shows that this multiphonic variant relates very well to the harmonic series on the low C sharp (Fig. 3.9) and the 7th and 11th notes in the series, as expected, are flat in pitch. There are two frequencies in Fig. 3.10.a that move away from the harmonic series. In Fig. 3.9 the 13th and 14th notes in the series are an A tuned sharp and a B tuned flat, whereas in Fig. 3.10.b we can see that a B flat that is flat in pitch appears. In the practical analysis, the C sharp that is overblown appears as the most prominent frequency, but the notes on either side of it (the B sounding flat in pitch and the D sharp) also appear as prominent frequencies. We can see that the practical results for variant A on a low C sharp are different to the way in which variant on a low C worked (Fig. 3.4.g).

### **Low C sharp multiphonic B (variant 2)**

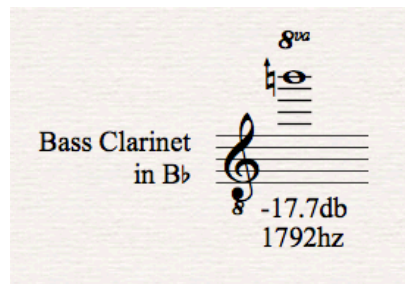
**Figure 3.11.a: Suggested notation**



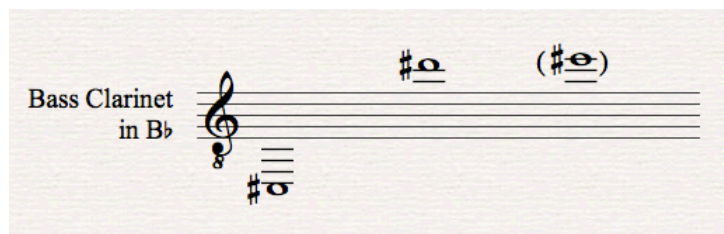
**Fig. 3.11.b: Notated theoretical results**



**Figure 3.11.c: Prominent frequencies out of usual written range of the instrument**



**Figure 3.11.d: Practical analysis of the most prominent readings**



For this variant, we can still relate the frequencies shown in Fig. 3.11.b directly to the harmonic series in Fig. 3.9. The problems with this multiphonic arise when comparing the practical result in Fig. 3.11.d to the chord that the performer is aiming to play (Fig. 3.11.a). The results show that, as in this variant for low C (Fig. 3.5.g), the major third of the C sharp chord (an E sharp) doesn't appear as the strongest fundamental. Instead, for this multiphonic variant, a D sharp next to the E sharp is the strongest partial. The E sharp is present but the D sharp is much stronger.

### Low C sharp multiphonic C (variant 3)

Figure 3.12a: Suggested notation

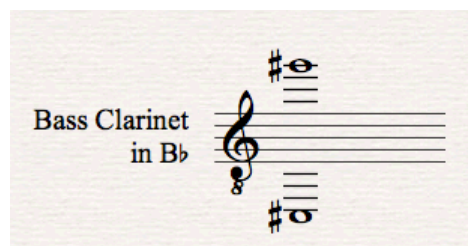
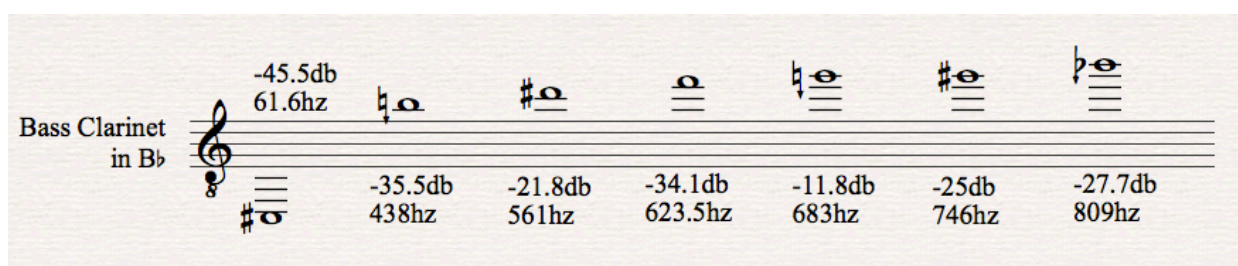
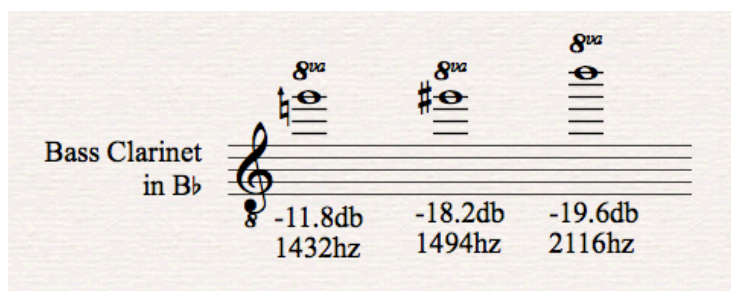


Figure 3.12.b: Notated theoretical results



**Figure 3.12.c: Prominent frequencies out of usual written range of the instrument**



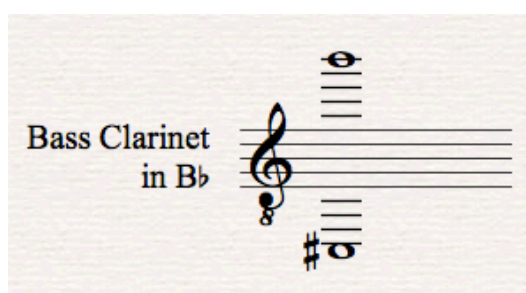
**Figure 3.12.d: Practical analysis of the most prominent readings**



We can compare the results for this variant (Fig. 3.12.d) to the results for the same variant on a low C (Fig. 3.6.g). As before, the 5th degree of the chord, a G sharp, doesn't appear as a dominant frequency (Fig. 3.12.b), although it does appear an octave higher and out of played range (Fig. 3.12.c). Again, like the low C variant, the note next to the G sharp – this time a G tuned flat (which fits with the harmonic series in Fig. 3.9) – is the most audible frequency.

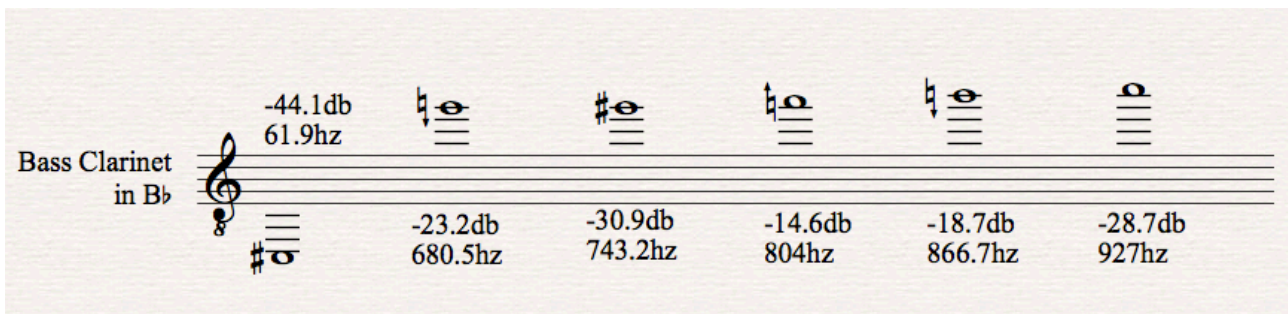
#### **Low C sharp multiphonic D (variant 4)**

**Figure 3.13.a: Suggested notation**

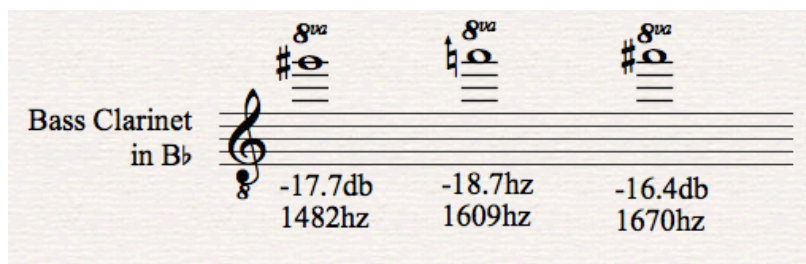




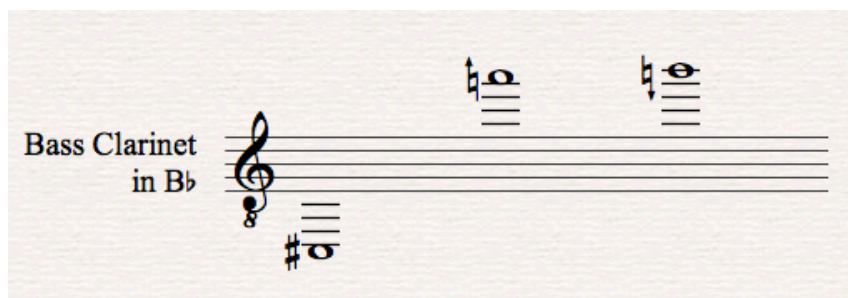
**Figure 3.13.b: Notated theoretical results**



**Figure 3.13.c: Prominent frequencies out of usual written range of the instrument**



**Figure 3.13.d: Practical analysis of the most prominent readings**



The theoretical results (Fig. 3.13.b) for this frequency are in accordance with the harmonic series in Fig. 3.9. We can see the practical results in Fig. 3.13.d, which show that the overblown B (shown in Fig. 3.13.a) is present as one of the most dominant frequencies

and is flat in pitch, which is expected and is also shown in the harmonic series. The most audible frequency is not the B, but the A next to it, which again is in accordance with the harmonic series, although it is pitched slightly high.

### Low C sharp multiphonic E (variant 5)

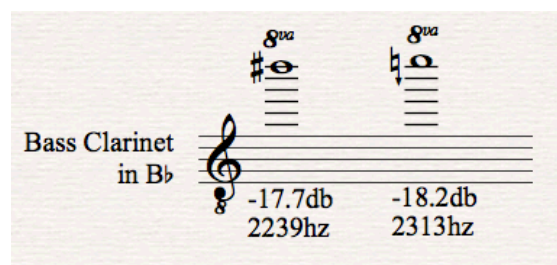
Figure 3.14.a: Suggested notation



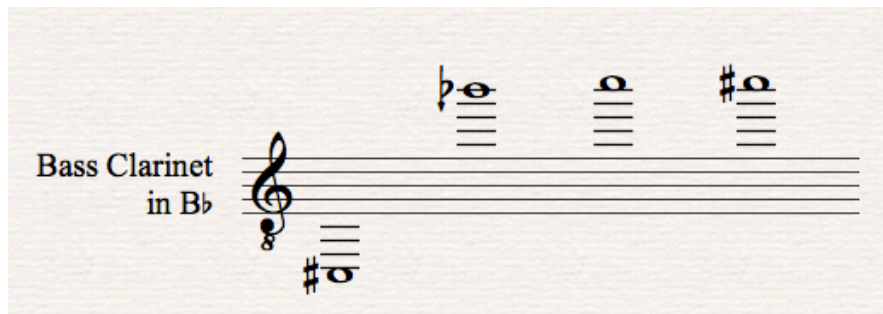
Figure 3.14.b: Notated theoretical results



Figure 3.14.c: Prominent frequencies out of usual written range of the instrument



**Figure 3.14.d: Practical analysis of the most prominent readings**



In this final variant on low C sharp, again we see that, theoretically (Fig. 3.14.b), it fits around the harmonic series (Fig. 3.9), which is as expected. The only slight deviation is the high B flat sounding flat at around 808Hz. Technically, this should be a natural-sounding A sharp. The C sharp four octaves above the fundamental that is being overblown (Fig. 3.14.d) is present as the most dominant frequency, however. We can also see from the practical results that it is surrounded by the flat-sounding B flat and the C sharp, which are also prominent frequencies.

Fig. 3.15 shows the harmonic series notation chart for low D.

Figs. 3.16.a, 3.17.a, 3.18.a, 3.19.a and 3.20.a show suggested notation for the multiphonic being analysed with the top note of the chord that the performer is overblowing and aiming to produce.

Figs. 3.16.b, 3.17.b, 3.18.b, 3.19.b and 3.20.b show the theoretical notations of the most prominent frequencies between 0db and -40db.

Figs. 3.16.c, 3.17.c, 3.18.c, 3.19.c and 3.20.c show very prominent out-of-range frequencies that are produced for the multiphonic.

Figs. 3.16.d, 3.17.d, 3.18.d, 3.19.d and 3.20.d show a more practical notation of only the strongest frequencies that are present in the chord being played.

Figure 3.15: Low D harmonic series

Figure 3.15 displays the Low D harmonic series across three staves. The top staff is for Bass Clarinet in B $\flat$ , showing notes 1 through 8. The middle staff is for B. Cl., showing notes 9 through 14. The bottom staff is also for B. Cl., showing notes 15 through 20. Each note is represented by a musical note on a staff with its corresponding fingering or octave marking below it.

Low D multiphonic A (variant 1)

Figure 3.16.a: Suggested notation

Figure 3.16.a shows the suggested notation for Low D multiphonic A (variant 1) on a Bass Clarinet in B $\flat$ . The notation consists of a single musical note on a staff with a treble clef and a key signature of two flats, accompanied by a fingering diagram below it.

Figure 3.16.b: Notated theoretical results

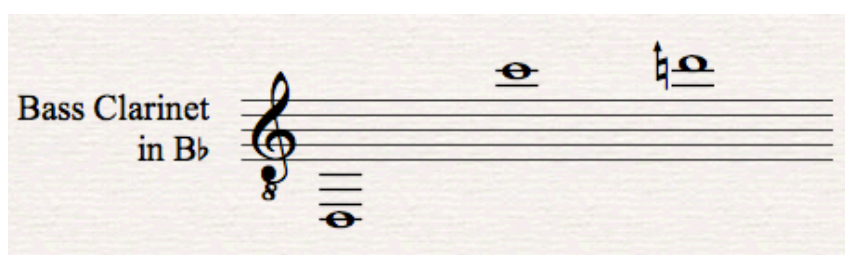
Figure 3.16.b shows the notated theoretical results for Low D multiphonic A (variant 1) on two staves. The top staff is for Bass Clarinet in B $\flat$  and the bottom staff is for B. Cl. Each note is accompanied by its theoretical frequency in Hz and its dynamic level in dB.

Staff	Note	Frequency (Hz)	Dynamic (dB)
Bass Clarinet in B $\flat$	1	65.7	-35
Bass Clarinet in B $\flat$	2	198.7	-30.5
Bass Clarinet in B $\flat$	3	334.5	-26.8
Bass Clarinet in B $\flat$	4	467	-12.7
Bass Clarinet in B $\flat$	5	533.4	-19.1
B. Cl.	9	599.7	-27.7
B. Cl.	10	1000	-24.6
B. Cl.	11	1066	-30.9
B. Cl.	12	1137	-25.5
B. Cl.	13	1199	-25.5
B. Cl.	14	1269	-31.4

**Figure 3.16.c: Prominent frequencies out of usual written range of the instrument**



**Figure 3.16.d: Practical analysis of the most prominent readings**



When the theoretical notation (Fig. 3.16.b) for this particular variant on low D is compared to the harmonic series of a low D, it can clearly be seen that the basic pitches relate to the harmonic series; however, when we analyse the intonation of each frequency it becomes evident that many frequencies in the series are around an 1/8 tone sharp in pitch. This is possibly due to the low D naturally being an out-of-tune note; however, it should be observed that at 65.7Hz the low D fundamental is in fact only a fraction too high in pitch (it is not even an eighth tone high). When these results are put into a practical chart (Fig. 3.16.d), the results show that C is the most prominent frequency, and the overblown D is also one of the most dominant notes.

## Low D multiphonic B (variant 2)

Figure 3.17.a: Suggested notation

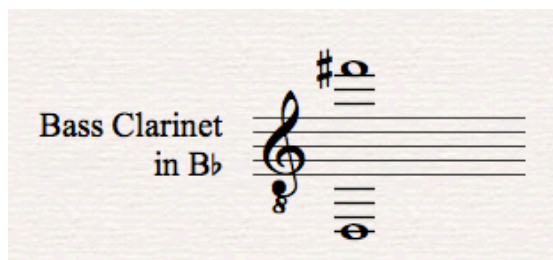


Figure 3.17.b: Notated theoretical results

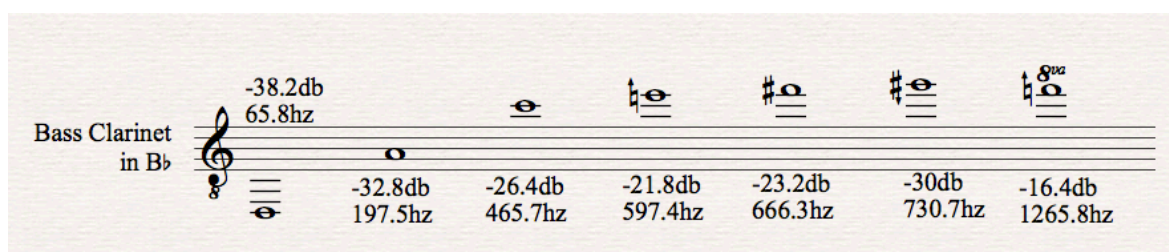


Figure 3.17.c: Prominent frequencies out of usual written range of the instrument

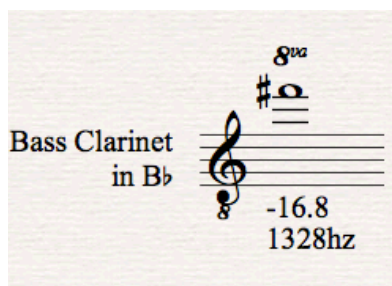
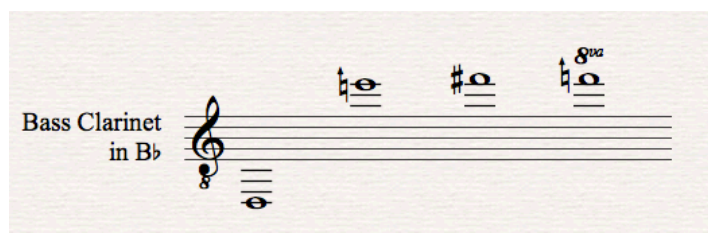


Figure 3.17.d: Practical analysis of the most prominent readings



For this variant on a low D, we see similar results to the other second variants analysed so far (Fig. 3.5.g and Fig. 3.11.d). Again, it is evident that the note the performer is aiming to produce in Fig. 3.17 – in this case an F sharp three octaves above the fundamental – isn't the strongest frequency and, as seen before, a note close to the F sharp (this time an E pitched sharp) is the more prominent, as shown in Fig. 3.17.b. The F sharp is present and is very close in terms of decibels to the E. The most prominent partials are at the limits of the playable range, with an example of this being a high F that is pitched sharp (Fig. 3.17.c)

### Low D multiphonic C (variant 3)

Figure 3.18.a: Suggested notation

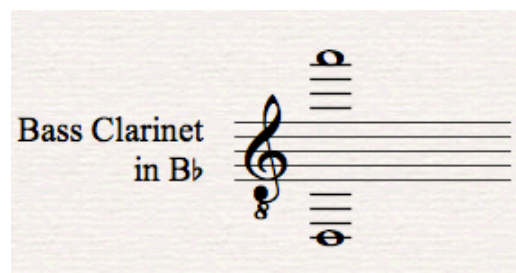
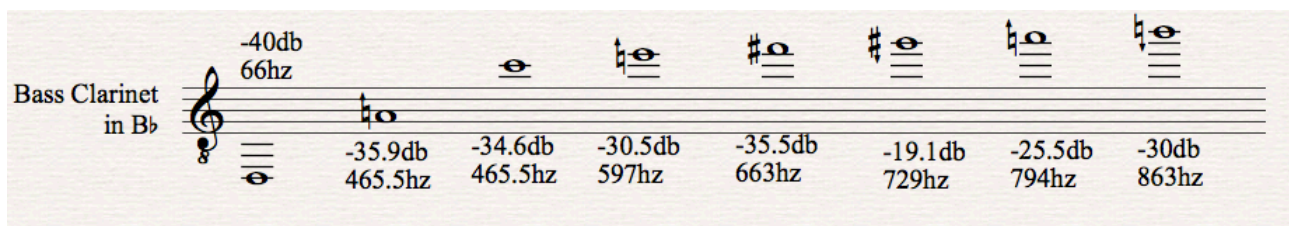
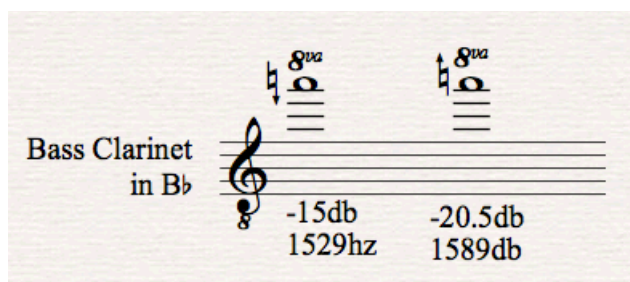


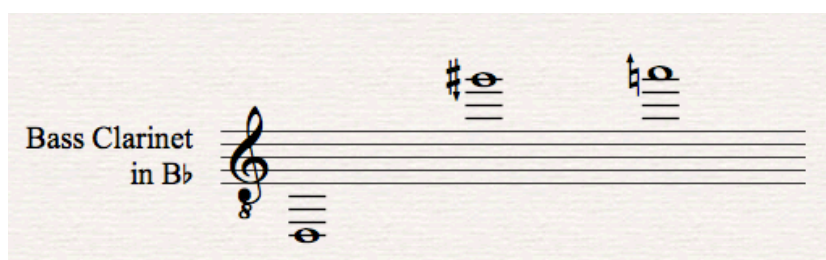
Figure 3.18.b: Notated theoretical results



**Figure 3.18.c: Prominent frequencies out of usual written range of the instrument**



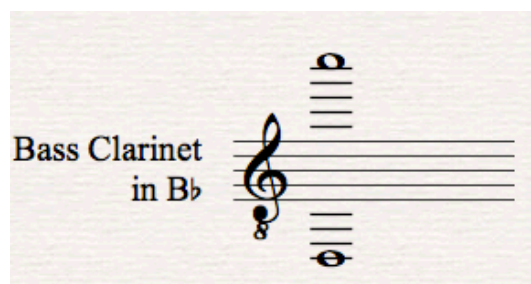
**Figure 3.18d: Practical analysis of the most prominent readings**



For this variant, again we can see that many of the pitches (Fig. 3.18.b) have shifted to being sharp in pitch when related to the harmonic series. The fundamental low D has also sharpened very slightly to 66Hz, but it is still not at 66.3Hz, which would register it as an eighth tone sharp. Because of this pitch shift, the overblown A appears slightly sharp and is not at the most dominant pitch, which is the G sharp next to it that is slightly flat (which does fit with the harmonic series in Fig. 3.15).

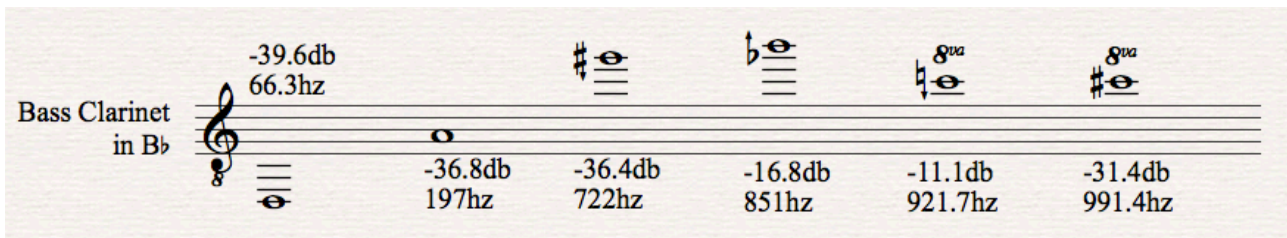
#### Low D multiphonic D (variant 4)

**Figure 3.19.a: Suggested notation**





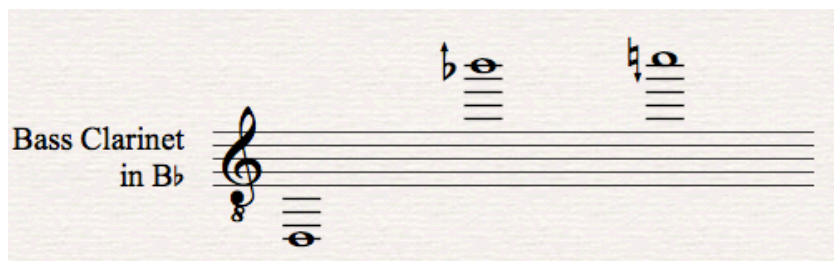
**Figure 3.19.b: Notated theoretical results**



**Figure 3.19.c: Prominent frequencies out of usual written range of the instrument**



**Figure 3.19.d: Practical analysis of the most prominent readings**



Once again, the results are fairly consistent with similar variants on the previous two low notes, and the theoretical results (Fig. 3.19.b) follow the harmonic series of Fig. 3.15. The overblown high C (Fig. 3.19.a) is the most dominant frequency and, like the same variants on low C and low C sharp, the note next to it – this time a B flat – is also very audible. In accordance with the harmonic series, the B flat is slightly high in pitch and the C is slightly under pitch.

## Low D multiphonic E (variant 5)

Figure 3.20.a: Suggested notation

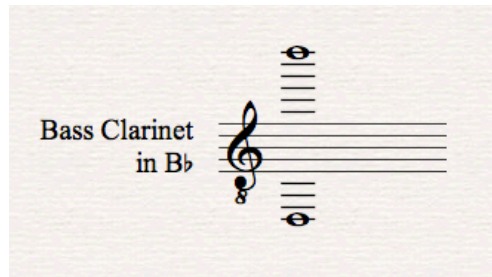


Figure 3.20.b: Notated theoretical results

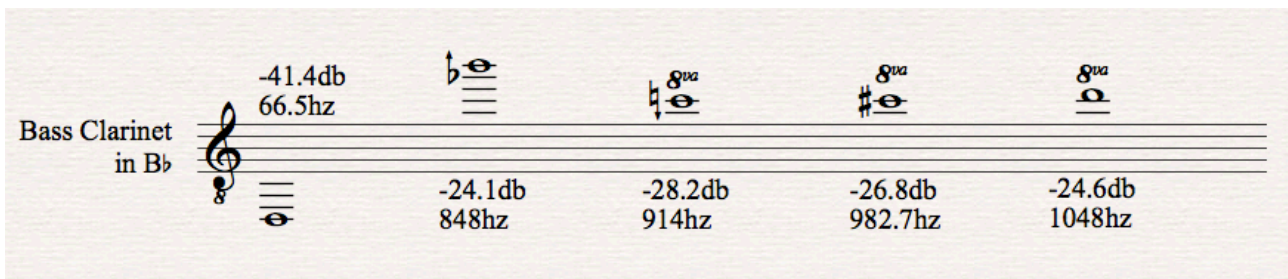


Figure 3.20.c: Prominent frequencies out of usual written range of the instrument

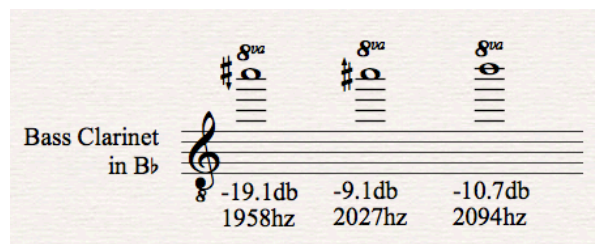


Figure 3.20.d: Practical analysis of the most prominent readings



For this variant on low D, we can see from the theoretical analysis (Fig. 3.21b) that the second to twelfth degrees of the harmonic series (Fig. 3.15) are not present at levels of 0db to 40db. Even the fundamental is only audible at a level of -41db. It is also important to note that all of most prominent frequencies are well above the played range of the bass clarinet, as seen in Fig. 3.20c where we can see that the high D an octave above the intended overblown D (Fig. 3.20a) is by far the most prominent frequency, together with the out-of-range C sharp next to it. For practical purposes, the intended overblown D is used (Fig. 3.20d), even though it is only audible at a level of around -24.6db.

Fig. 3.21 shows the harmonic series notation chart for low E flat.

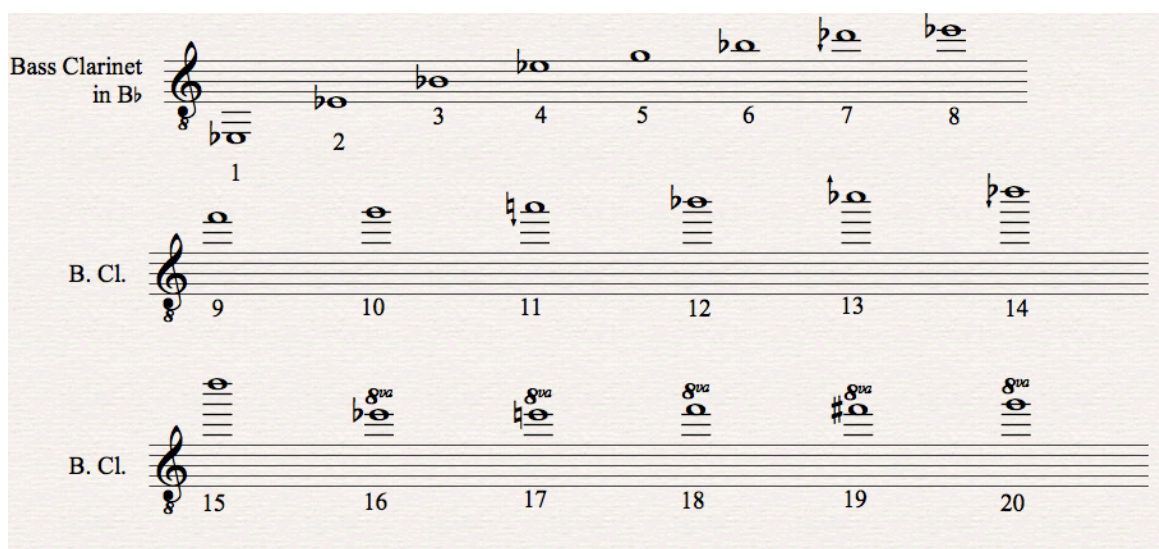
Figs. 3.22.a, 3.23.a, 3.24.a, 3.25.a and 3.26.a show suggested notation for the multiphonic being analysed with the top note of the chord that the performer is overblowing and aiming to produce.

Figs. 3.22.b, 3.23.b, 3.24.b, 3.25.b and 3.26.b show the theoretical notations of the most prominent frequencies between 0db and -40db.

Figs. 3.22.c, 3.23.c, 3.24.c, 3.25.c and 3.26.c show very prominent out-of-range frequencies produced for the multiphonic.

Figs. 3.22.d, 3.23.d, 3.24.d, 3.25.d and 3.26.d show a more practical notation of only the strongest frequencies that are present in the chord being played.

Figure 3.21: Low E flat harmonic series



Low E flat multiphonic A (Variant 1)

Figure 3.22.a: Suggested notation

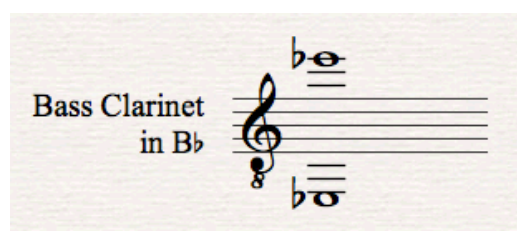
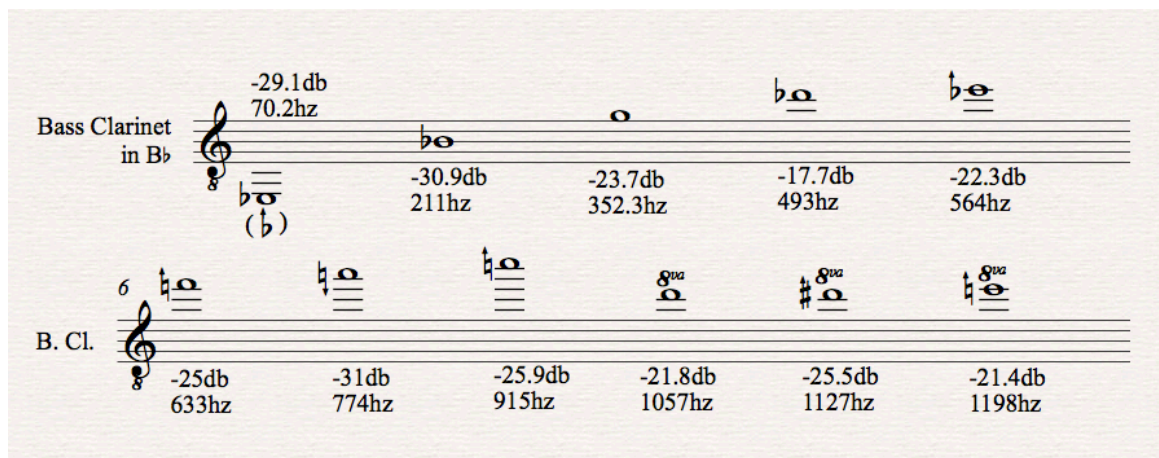
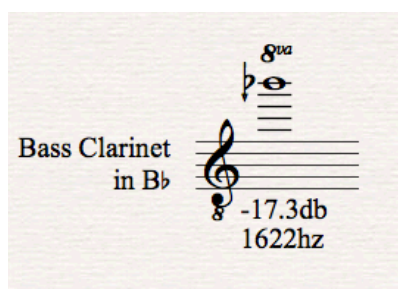


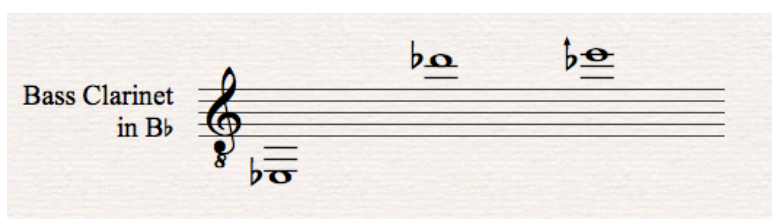
Figure 3.22.b: Notated theoretical results



**Figure 3.22.c: Prominent frequencies out of usual written range of the instrument**



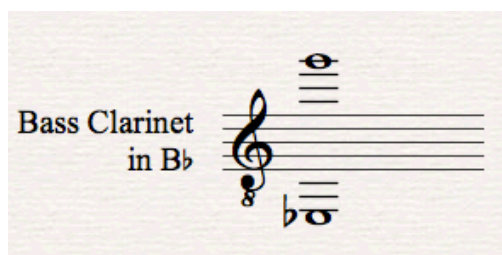
**Figure 3.22.d: Practical analysis of the most prominent readings**



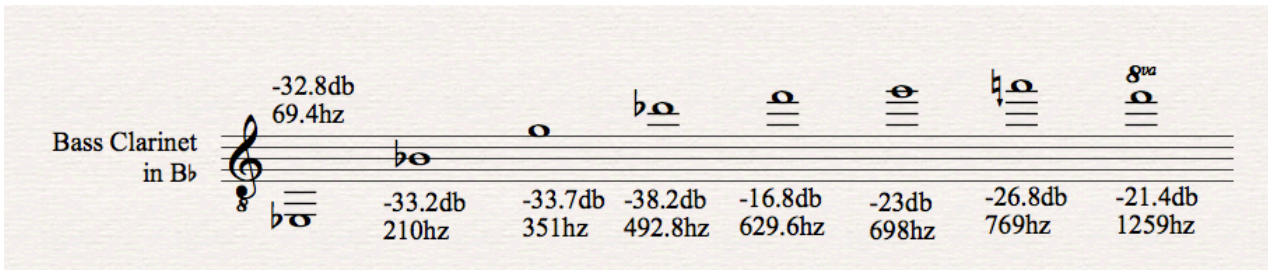
The results for this multiphonic variant on low E flat compare to the related variant on low D (Fig. 3.16.b and 3.16.d). As with low D, it can be seen that many partials become around an eighth tone sharp. Even the fundamental for this multiphonic is in fact around an eighth tone sharp; however, when compared to a straight low E flat recorded directly before this multiphonic was recorded, the straight E flat is only a fraction high in pitch (not even an eighth tone high).

### **Low E flat multiphonic B (variant 2)**

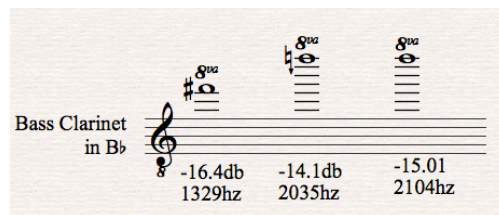
**Figure 3.23.a: Suggested notation**



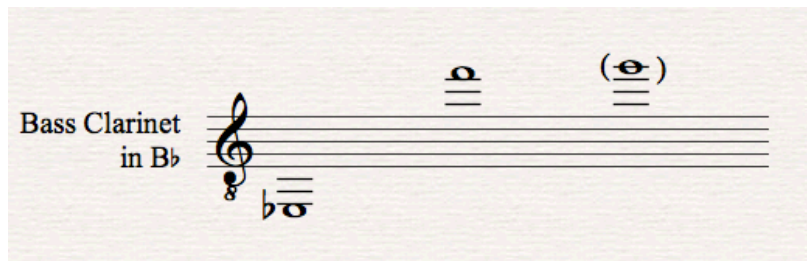
**Figure 3.23.b: Notated theoretical results**



**Figure 3.23.c: Prominent frequencies out of usual written range of the instrument**



**Figure 3.23.d: Practical analysis of the most prominent readings**



The analysis for this variant is consistent with the pattern shown for the previous second variants that have been analysed. Figure 3.23.a shows that the major third interval three octaves above the low E flat is the note that the player is aiming to produce and, as with the previous variants, F reading at -16.8db next to the G reading at -23db is the most prominent frequency. See Figs. 3.23.b and 3.23.d.

### Low E flat multiphonic C (variant 3)

Figure 3.24.a: Suggested notation

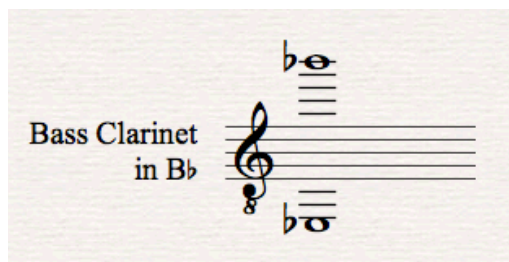


Figure 3.24.b: Notated theoretical results

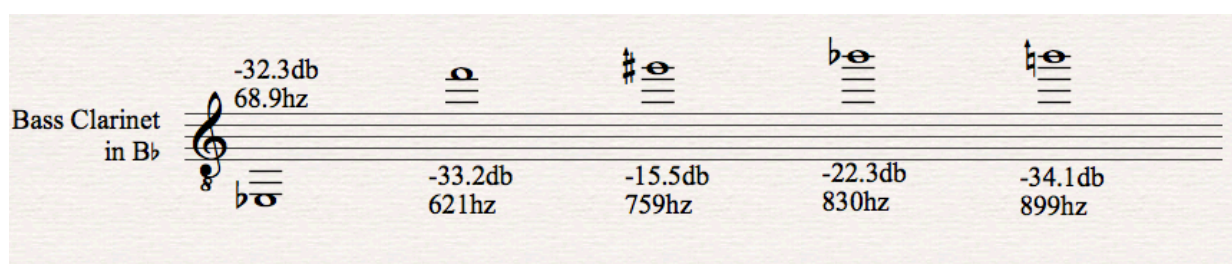


Figure 3.24.c: Prominent frequencies out of usual written range of the instrument

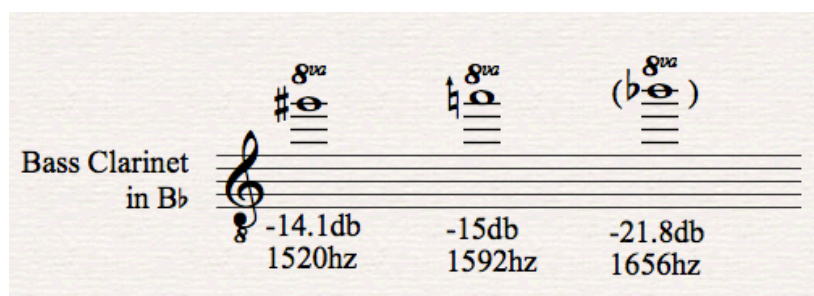
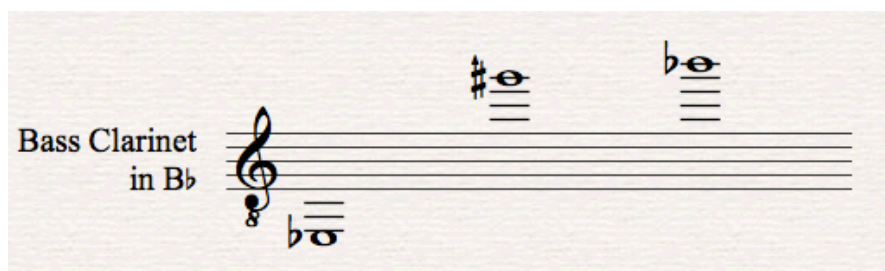


Figure 3.24.d: Practical analysis of the most prominent readings



All of the tones in this multiphonic fit with the harmonic series for the low E flat (Fig. 3.21). The overblown B flat (Fig. 3.24.a) is not the most prominent frequency but does appear now and is in tune. The most prominent in range frequency is the G sharp, which, in accordance with the harmonic series, is slightly sharp in pitch.

### Low E flat multiphonic D (variant 4)

Figure 3.25.a: Suggested notation

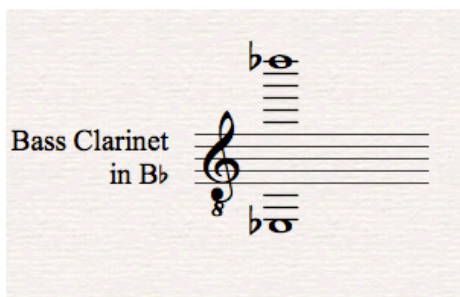
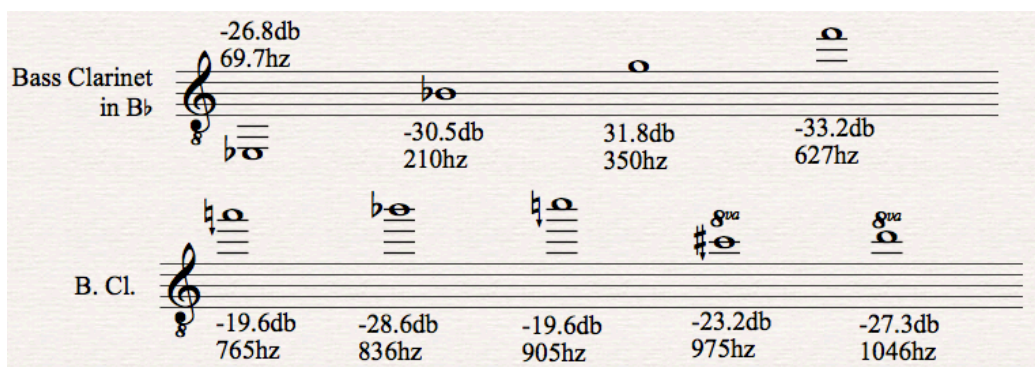
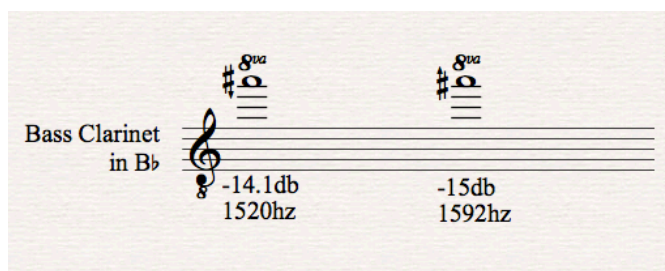


Figure 3.25.b: Notated theoretical results

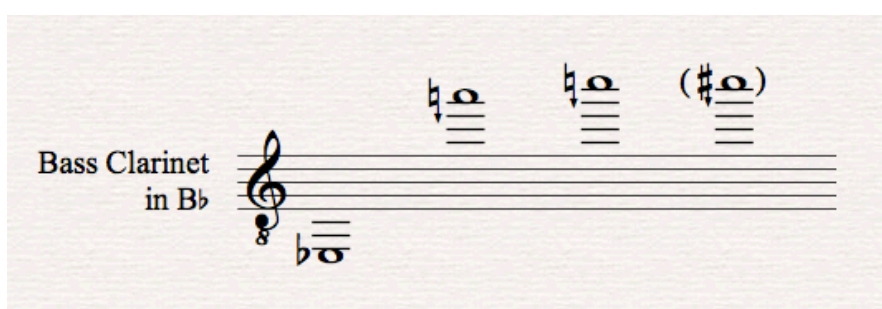




**Figure 3.25.c: Prominent frequencies out of usual written range of the instrument**



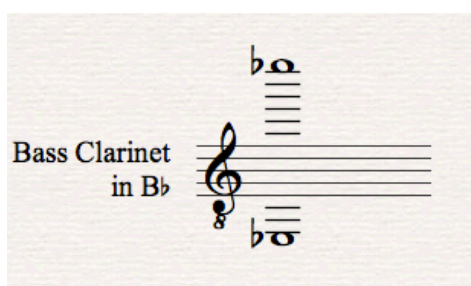
**Figure 3.25.d: Practical analysis of the most prominent readings**



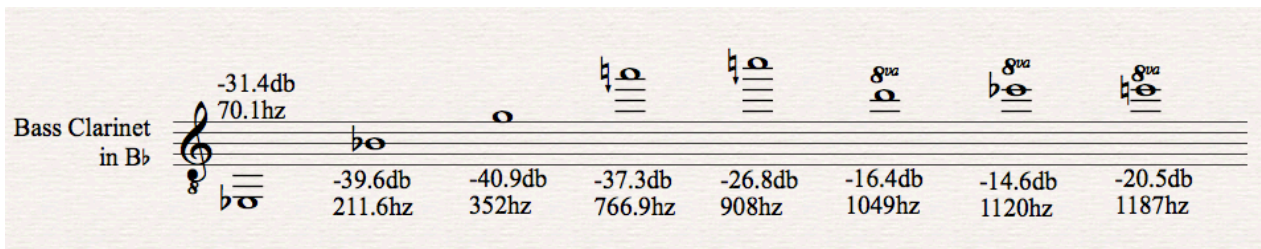
The results for this variant show that, again, the harmonics series partials (Fig. 3.25b) are evident in the practical results (Fig. 3.25.d), revealing that the overblown high C sharp/D flat (Fig. 3.25.a) is present and, as expected, is pitched flat, but they are not the most present partials, which are the A pitched flat and the B pitched sharp, just beneath the C sharp.

### **Low E flat multiphonic E (variant 5)**

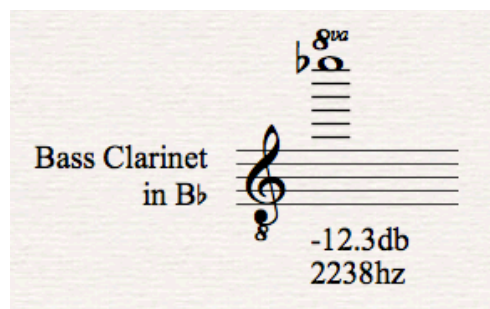
**Figure 3.26.a: Suggested notation**



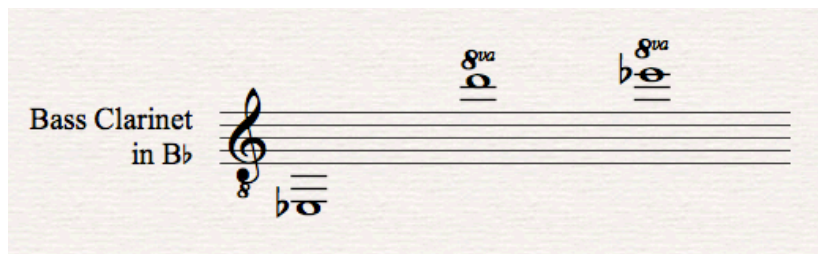
**Figure 3.26.b: Notated theoretical results**



**Figure 3.26.c: Prominent frequencies out of usual written range of the instrument**



**Figure 3.26.d: Practical analysis of the most prominent readings**



This multiphonic variant on low E flat shows similar results to the 5th variants on the low notes previously analysed. Again, if we look at the theoretical (Fig. 3.26b) and the practical results (Fig. 3.26d), we can see that the overblown low E flat four octaves above the fundamental (Fig. 3.26a) does appear as the most prominent frequency, with the D next to it also appearing to be very strong. As with the other five variants, there is a strong presence of the fundamental notes that are significantly above the played range of the

instrument. In this case, Fig. 3.26c shows a very audible E flat at 2238Hz, and this is more prominent in db than the intended overblown E flat.

Fig. 3.27 shows the harmonic series notation chart for low E.

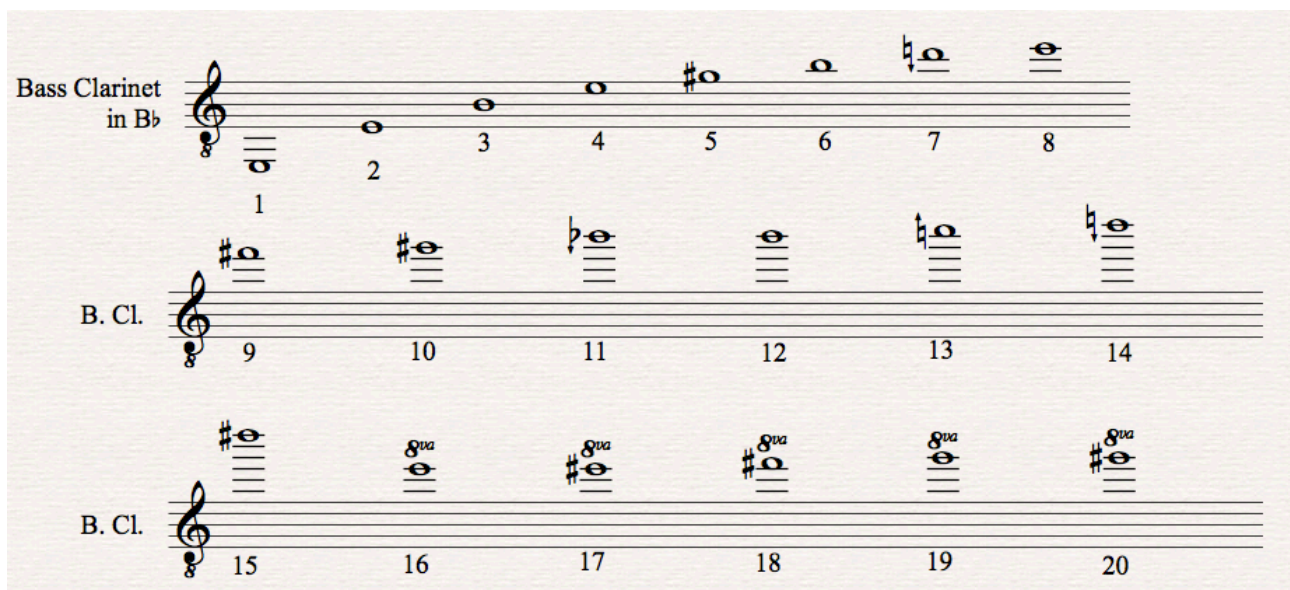
Figs. 3.28a, 3.29a, 3.30a, 3.31a and 3.32a show suggested notation for the multiphonic being analysed with the top note of the chord that the performer is overblowing and aiming to produce.

Figs. 3.28b, 3.29b, 3.30b, 3.31b and 3.32b show the theoretical notations of the most prominent frequencies between 0db and -40db.

Figs. 3.28c, 3.29c, 3.30c, 3.31c and 3.32c show very prominent out-of-range frequencies produced for the multiphonic.

Figs. 3.28d, 3.29d, 3.30d, 3.31d and 3.32d show a more practical notation of only the strongest frequencies that are present in the chord being played.

**Figure 3.27: Low E harmonic series**



## Low E multiphonic A (Variant 1)

Figure 3.28.a: Suggested notation

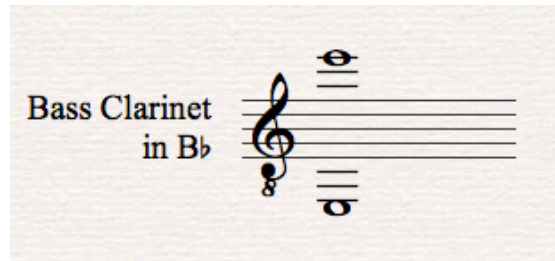


Figure 3.28.b: Notated theoretical results

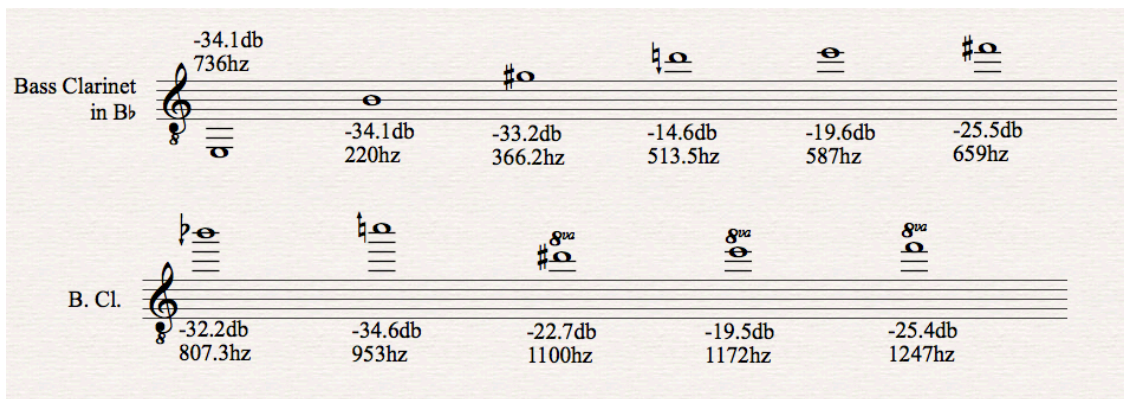


Figure 3.28.c: Prominent frequencies out of usual written range of the instrument

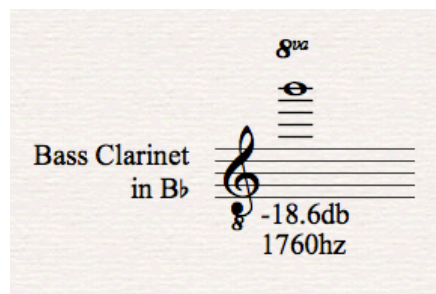
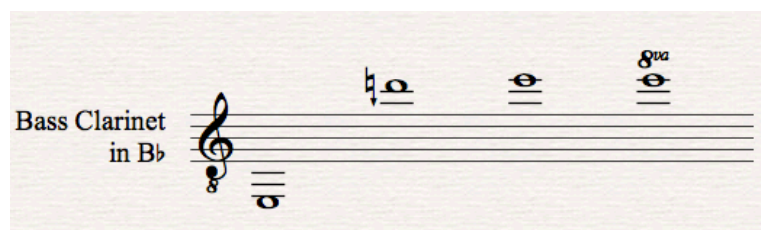


Figure 3.28.d: Practical analysis of the most prominent readings



The practical results of this multiphonic can be compared to the previous two practical results on related variants (Fig. 3.16.d and Fig. 3.22.d). For this multiphonic, however, we can see that the tuning issues of the previous two multiphonics on notes D and E flat have now disappeared and low E, when looked at closely, is in tune. Figure 3.28.d shows that the prominent D is back to being a flat pitched 7th and that the E being overblown is one of the strongest frequencies, as is the E four octaves higher.

### Low E multiphonic B (variant 2)

Figure 3.29.a: Suggested notation

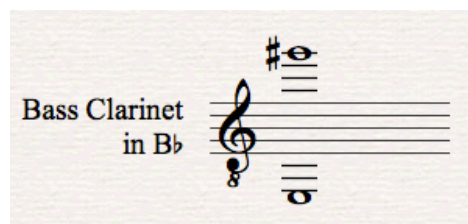


Figure 3.29.b: Notated theoretical results

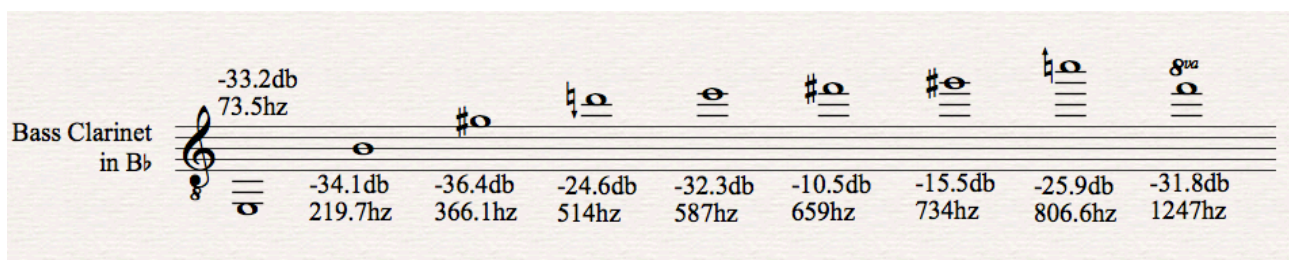
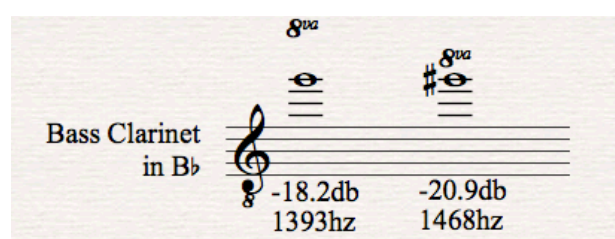
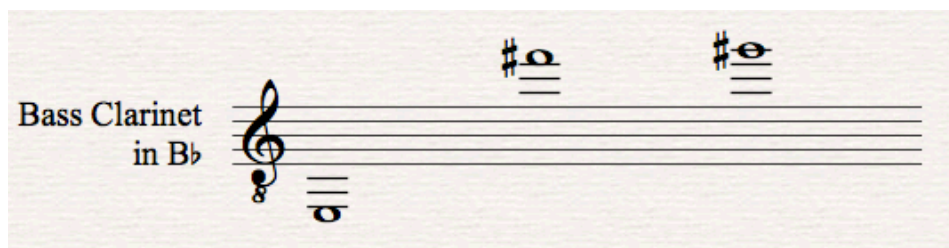


Figure 3.29.c: Prominent frequencies out of usual written range of the instrument



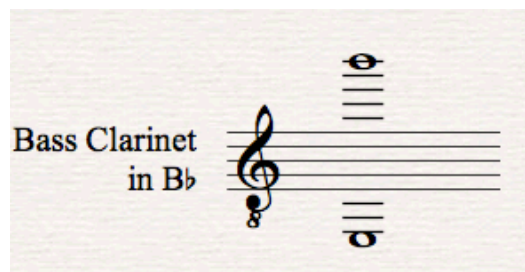
**Figure 3.29.d: Practical analysis of the most prominent readings**



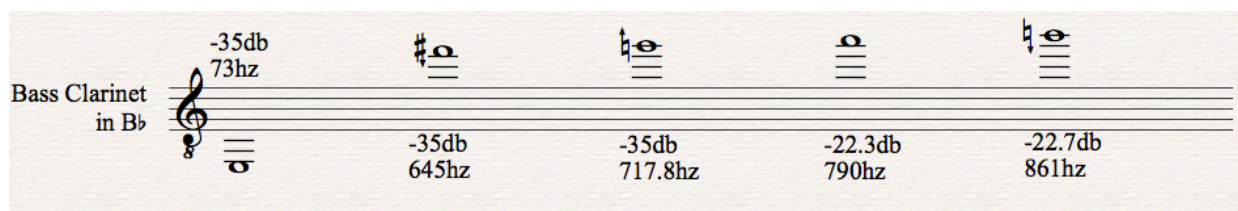
For this variant on low C, the results show that the G sharp being overblown (Fig. 3.29.a) is in fact a very strong partial. As with the previous multiphonics in this second variant, however, the most prominent partial is the F sharp directly below the G sharp.

**Low E multiphonic C (variant 3)**

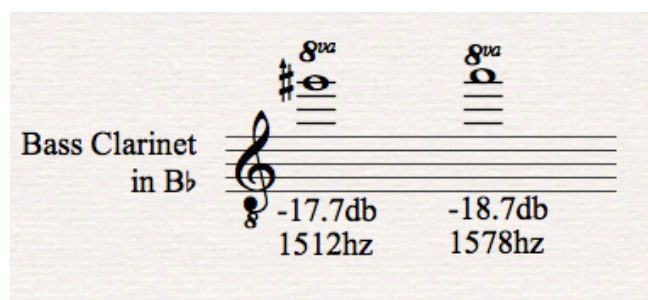
**Figure 3.30.a: Suggested notation**



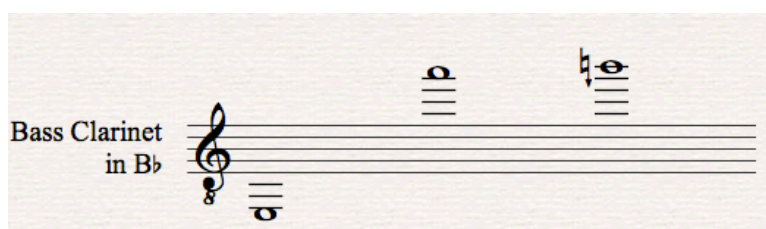
**Figure 3.30.b: Notated theoretical results**



**Figure 3.30.c: Prominent frequencies out of usual written range of the instrument**



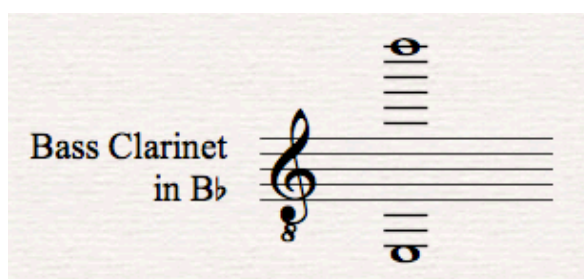
**Figure 3.30.d: Practical analysis of the most prominent readings**



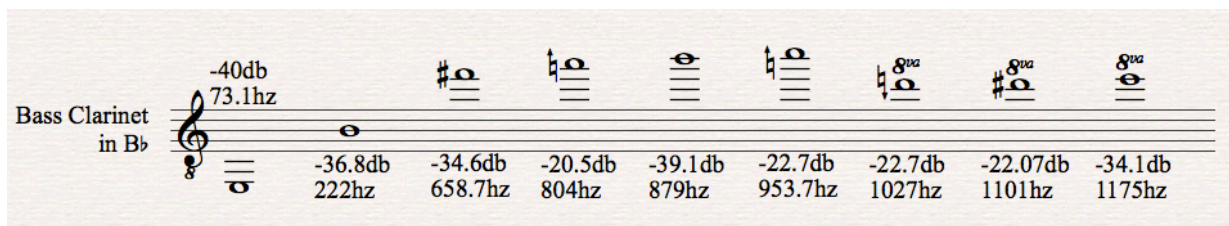
For this variant, the practical results (Fig. 3.30.b) show that there is a large hole in prominent partials in the harmonic series. Harmonies 2–8 are not present at 0db to 40db. It can also be seen that some of the partials present are not tuned to the rules of the harmonic series (compare Fig. 3.30.b to Fig. 3.27) and that the overblown high B is flat in pitch. The most prominent partials of 0db–20db are all out of played range, but within played range the overblown B is one of the more prominent notes.

#### **Low E multiphonic D (variant 4)**

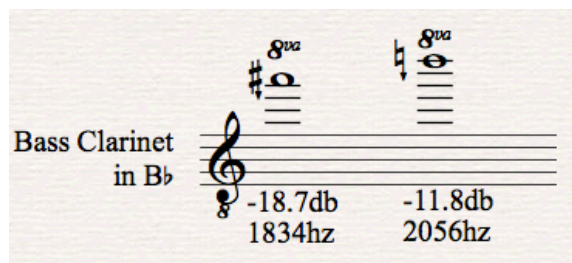
**Figure 3.31.a: Suggested notation**



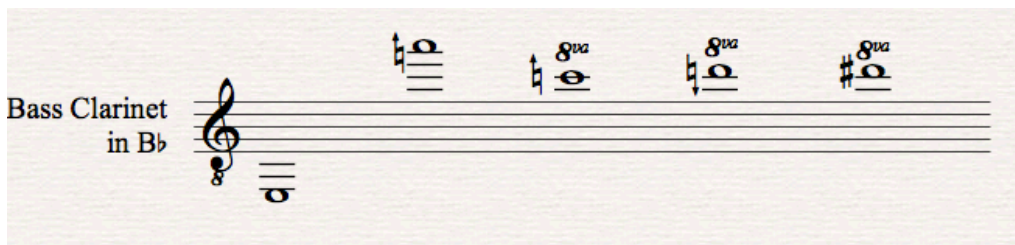
**Figure 3.31.b: Notated theoretical results**



**Figure 3.31.c: Prominent frequencies out of usual written range of the instrument**



**Figure 3.31.d: Practical analysis of the most prominent readings**



Most frequencies that are shown in Fig. 3.31.b fit with the harmonic series of Fig. 3.27, although the occasional note is not quite at the pitch expected. The overblown high D is one of the most prominent frequencies in the played range and is pitched as a flat-sounding 7th. It is surrounded by partials of very similar frequencies, and it should also be observed that the D an octave above the overblown D is well out of played range, but is by far the most prominent partial.



### Low E multiphonic E (variant 5)

Figure 3.32.a: Suggested notation

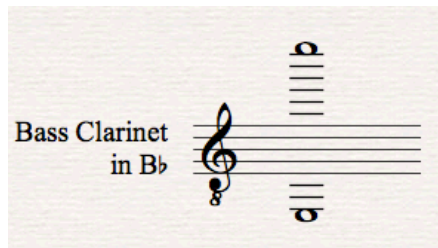


Figure 3.32.b: Notated theoretical results

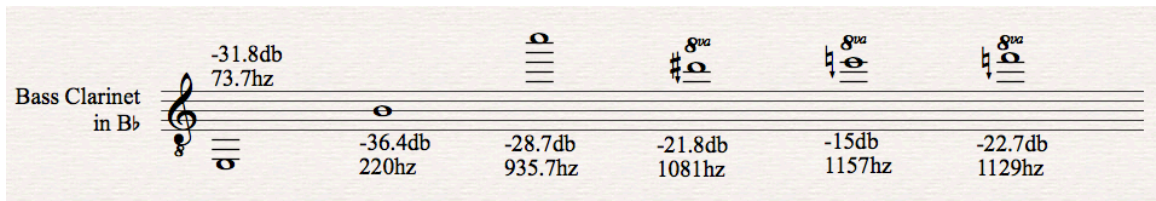


Figure 3.32.c: Prominent frequencies out of usual written range of the instrument

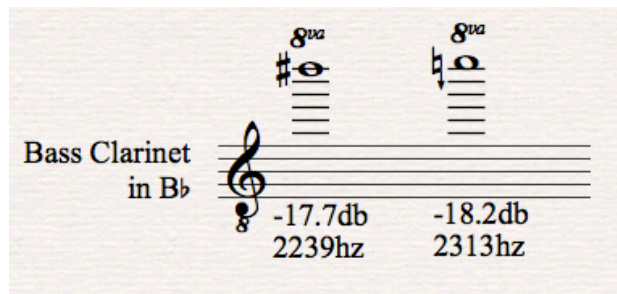
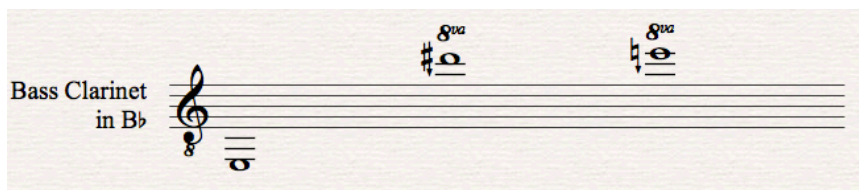


Figure 3.32.d: Practical analysis of the most prominent readings



This final variant analysed in this chapter shows that again the overblown note appears as the most prominent frequency, with the note next to it, the D sharp, also being very present (Fig. 3.32.d). They both appear flat in pitch; however, as the embouchure is very tight at this stage to get the multiphonic to sound as intended and the reed is being pushed to its limits, I conclude that this could be the main reason why the top pitches are reading under pitch at this stage. As in the other five variants, there is a very strong presence of out-of-range frequencies (Fig. 3.32.c), with the overblown E again appearing an octave higher as well.

## **Conclusions**

The results from the analysis of the five low notes and the five variants has proven that the harmonic series remains generally central to their make-up. By analysing five variants on each note, it can be seen very clearly on the spectrograms and also in the theoretical and practical results that changing the embouchure to produce a different variant multiphonic alters the sound spectrum of the initial low note and the different variants. The more pressure that is put on the reed by changing the embouchure, the higher the strongest frequencies which are above the playable range of the instrument at times. The reed can affect the upper partials as the player plays up the scale and up the variants. This is best seen in the E flat multiphonic, variant five (Figs. 3.26a-3.26d), when the reed is at the limits of what it can produce.

An in-depth analysis of these multiphonics has come up with a mixture of expected and unexpected results that have strongly justified the time spent in analysing how this type of multiphonic for the bass clarinet works.

As performers, we are trained to think carefully in terms of the harmonic series with regard to playing and overblowing these multiphonics, but the results from the analysis on the examples in this chapter show that whilst most of the time the Type One multiphonics

follow the harmonic series in terms of over blown harmonics, certain notes and certain variants produce results that are not always consistent with the harmonic series of the note in question.

An in-depth look into Type One multiphonics and variants on them has resulted in evidence that shows that what a performer is aiming to produce doesn't always end up sounding as such. It would be very impractical, however, to notate these multiphonics to read in the way that was shown in the practical and theoretical chart results due to a number of factors, as listed below:

1/ It would become impossible for a performer to pitch some of the intervals that arise between the fundamental notes and the most prominent frequencies, especially when some of the prominent frequencies appear as quarter and eighth tones.

2/ My results show very clearly that the bass clarinet is not always consistent in terms of intonation. Some notes are more in tune than others in this range of the instrument. This will also apply to other instruments and will vary from instrument to instrument; in addition, there will also be differences because of different mouthpieces and reeds.

3/ These are the results of one player. Type One multiphonics are very dependent upon embouchure, the reed, the acoustics of the room and the player's ability to be able to produce them. There are many factors that influence and slightly change the results, and it is vital that composers know and understand this when composing using Type One multiphonics. Another player may find that other frequencies emerge from the multiphonic. Harry Sparnaay restates the flexibility needed to be realised by composers when working with both these and Type One multiphonics:

'The problem is with multiphonics and not only with Type One – but with Type One you are making the multiphonic with your lip. Multiphonics I think are the most difficult and the most

risky thing we have for our instrument because – and I hope I was clear in my book – it is your results when you are writing<sup>69</sup>.’

The word flexibility is key to this whole area and to the success of this and in the future, so it is worth restating..

The analysis for this section on Type One multiphonics was carried out using a Selmer Privilege bass clarinet with a Louis Rossi wooden bell, a Pomarico crystal HB cut mouthpiece, a Florian Popa wooden ligature and strength 3.25 Gonzalez reeds. The combinations of bass clarinets, mouthpieces, ligatures and reeds that could be used to compare the above set-up is too big to even consider, even before we talk about personal factors such as the difference in players’ embouchures and oral cavities, or the difference that humidity levels or acoustics in concert halls and practice rooms can have on these multiphonics. It can certainly be said that the Type One multiphonics are ‘safe’ to play and that it can be assumed that many proficient players can play them and the variants above them, plus many additional variants, depending on which reeds are used. It should also be observed, however, that due to the number of different variants on these multiphonics and all of the additional factors noted above, composers should be very aware that the results from the analysis of the five variants above will not be exactly the same for each player. Some players will produce more frequencies and some players will get fewer frequencies, and different factors will influence the tuning and intonation of such factors.

Because these multiphonics are so flexible with regard to the number of variants that can be overblown on them, some caution should be taken when using them as a compositional tool. When they are used as an effect, and when the composer gives the player the freedom to choose variants (for example as a colour effect), then these are very flexible multiphonics. Composers should be aware, however, that asking players to play precise

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<sup>69</sup> Harry Sparnaay, Interview with Sarah Watts, Barcelona, 28th May 2011.

variants in compositions could, for the reasons already explained, result in unsuccessful performance results. There will be further written examples of Type One multiphonics in later chapters that demonstrate how Type One multiphonics have been successfully used in compositions.

Following this research, and as a performer, I would advise composers to consider the way in which most performers think about these multiphonics so that they write them as I have suggested in the above notations (i.e. as intervals based on the harmonic series) and to be aware that there will, without question, be more frequencies sounding than are written down and that this may vary between instruments, as will exact pitches. Individual circumstances, as explained above, such as reeds, humidity and acoustics, may also affect the stability of exact pitching in pieces. It should also be noted that after the low note E, the fourth and fifth variants become harder to control as the instrument and reed reach the limits of the playable range.

The analysis of the Type One multiphonics has highlighted certain characteristics and technical issues that occur on the bass clarinet. Before I started this chapter and my research, I felt certain that these multiphonics would be easy to analyse and understand, having spent much of my career practising and playing them and making assumptions about them. The results have enlightened and changed my thoughts on the bass clarinet and how it works, and have really made me think, not only about how I play and approach multiphonics, but also about normal, straight notes. The research so far has certainly strengthened my understanding of the instrument and made me respect what it can offer players and composers.

## Chapter 4

### Type Two multiphonics

As seen in chapter three, this research project uses electroacoustic technology to look at and analyse both types of multiphonics. This chapter describes the process of analysis and the creation of new, accurate charts for Type Two multiphonics. The use of these new SW charts in practice is demonstrated in existing works and new études and pieces in chapter five. The findings and resulting charts from this analysis will be a useful compositional tool for composers in the future, and performers will be able to refer to the charts confidence in the knowledge that they are transposed and accurate.

Many decisions needed to be taken about which features of each multiphonic to include in and which features to leave out of the final SW charts. These influences also played a large part in how I came to make decisions about the final notations for each multiphonic. The final set of SW charts can be seen in full in Appendix 1.

Earlier feedback, as discussed in chapter two, indicated that in general performers and composers would like additional information for each multiphonic other than just the notation of frequencies in each multiphonic. I decided that other than audio samples accompanying each multiphonic, they would not include certain aspects of extra information. The reasons why I decided to leave out other factors are discussed below:

#### **Embouchure pressure and air/blowing pressure**

Some performers suggested that it would be useful to have an indication of how relaxed or tightly one should place one's embouchure and how much air pressure should be used when executing each multiphonic. After spending many hours practising' multiphonics and learning each one, it is very difficult to give an accurate guide as to how much pressure

should be used in terms of both the embouchure and the air when playing them. I believe that each multiphonic has to be learnt in the same way that a straight single note is learnt and that in the end this comes down to each player's individual technique and, ultimately, an instinctive feeling for how and where to place each one technically. This is true of my own experience, but this advice occasionally may not always work for others. The same is true, to an extent, for each notation I have arrived at for each multiphonic – an incorrect playing position may alter the make-up or result in the multiphonic being played incorrectly. It is important to remember the words of Harry Sparnaay quoted in the Introduction of this thesis (page 1).

It is also of the utmost importance not only to talk about embouchure pressure, but also to state that pressure isn't about biting or squeezing the embouchure. There is also a relationship between the two concepts of pressure and position. Henri Bok has pointed out important differences between embouchure position and pressure, which affect the successful outcome of all multiphonics – both Type One and Type Two:

'I know in my book I speak about pressure (on the embouchure), but I have changed my mind about that since many years, and it's really about finding the right spot to get the right overtones. You should never bite or have too much pressure on the reed. Your position for the third register, the fourth register overtones might be different from mine (for Type One multiphonics) but still you find it's like you can compare it with the violin or another stringed instrument. If you changed violin then you might put your finger in a slightly different position to get a certain tone in tune and correct<sup>70</sup>.'

This is a very good analogy and helps to explain the subtle changes that different players have with their embouchures when playing a multiphonic.

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<sup>70</sup> Henri Bok. Telephone interview with Sarah Watts, 10 February 2013

Chapter five shows how multiphonics can be effectively used in practice and includes a set of mini études. A big incentive for commissioning études is that it is very rare that a player will practise the technique of multiphonics. A player will spend many years improving numerous areas of technique – breathing, breath control, tone quality and production, the quality of soft and loud dynamics and articulations, etc. Other than practising many techniques in the context of a performance repertoire being learnt and initial practice to achieve the execution of contemporary techniques, it is not common for a performer to practise an étude or to do exercises to improve their understanding of many such techniques. This can certainly be said of multiphonics, and to execute a multiphonic perfectly they need to be practised just as much, if not more so, than just a single note. External issues such as reeds and acoustics will affect the production of a multiphonic even more than just a single note, so in theory a performer should compensate for this complication by learning the technique of multiphonics thoroughly.

In addition to the individuality of the player, it is important to consider the general set-up and the differences in personal set-up when passing advice to others about air pressure and embouchure. My own personal set-up used throughout this research is a very open, cut Pomarico crystal mouthpiece, Argentinean Gonzalez reeds or French Vandoren reeds and a Florian Popa ligature. Towards the end of writing this thesis, final trials and performances were done using an open cut Vandoren B50 mouthpiece. Each performer will approach a multiphonic in a different way on each mouthpiece, whether they are using a closed or open mouthpiece or a different make of reed and ligature. When trying other makes of mouthpieces, reeds and ligatures when playing just single notes, the whole embouchure changes in subtle ways, as does the amount of air pressure and support used. This change is likely to be even more marked in the field of multiphonics. I have tested each multiphonic on four different makes of Selmer bass clarinet and on a modern



Buffet, and I have to adapt my playing to these instruments, even with my own individual mouthpiece, reed and ligature set-up.

### **Ease of production**

Many composers asked for information on the time it takes for each multiphonic to sound and the difficulty in rating of each of them. The decision was made early on in my research not to include this information, as different players will undoubtedly have different opinions to me about certain multiphonics. Again, instrument set-up, acoustics, the individual performer, playing conditions and the pressure of performance can all have continually changing effects on the production of each multiphonic. What is easy and responsive during practice or in a rehearsal can suddenly become difficult and unreliable in concert. Factors such as a reed going soft or wet during the concert, performance nerves and the pressures of performing live, and hot stage lights can all play a part in how the instrument, reed and multiphonic (or in fact any note) can react on the day.

### **Quarter and eighth tone breakdown with exact hertz<sup>71</sup> frequency breakdown details**

Some composers requested that I detailed the frequency breakdown in multiphonics to eighth tone notation and also listed the exact Hz reading, because they thought that was important. I have taken the decision to simply notate each frequency in the multiphonic as a simple 'higher or lower than tuning' rather than trying to notate accurate quarter and eighth tones. An accidental with an arrow pointing up sounds sharp and a note with an arrow pointing down is slightly flat. I kept an open mind during the first stages of analysis, but it soon became obvious that to attempt to notate intervals down to eighth tone intervals was not possible and would quickly render the charts inaccurate.

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<sup>71</sup> Hertz is a unit used to measure frequency

There are a number of factors that contributed to the decision that it would not be possible to notate to this detail completely accurately, nor would such detail be reliable. When I was breaking down the frequencies and working out the exact pitches, many notes fell in between an eighth and a quarter tone. Making a decision on what to notate was very much my decision and may not suit what others would choose. Also, it is of the utmost importance that composers realise that when I recorded the multiphonics in preparation for analysing them via *Audiosculpt*, I tried to always keep my tuning to A=440. As with any wind instrument, however, the more I play, the sharper in pitch the instrument becomes. Another important factor that composers and possibly performers must realise is that bass clarinets are not even perfectly in tune with themselves. Certain notes on a bass clarinet can be very out of tune naturally, and whilst playing a passage or a scale of single notes a performer must individually tune each note whilst playing. When playing a multiphonic, the performer loses control of the ability to tune the instrument. Whilst this wouldn't become an issue with notating and deciding whether a certain frequency is slightly sharp or slightly flat overall, a minute change in my overall tuning pitch over a recording session may well render an eighth tone difference at different times during the session. When we then look at different acoustics and different tuning frequencies across the world, i.e. A=440, A=442 and A=444, we already find variations that can push potential eighth tone notations into a grey area. Whilst it is possible for a performer to accurately execute an eighth tone scale in the confines of the particular instrument they are playing, again taking into account the tuning restraints of each individual instrument, I believe that it is not possible to successfully break down a multiphonic into accurate eighth tone pitching without the risk of becoming inaccurate.

The frequency breakdowns I did for the purpose of analysis are purely practical, and decisions about whether a note is slightly sharp or flat were based on my results and the recording on the day. It may be that on occasions some players may find very slight

inconsistencies or may find, for example, that a fundamental that is notated as slightly sharp or slightly flat may be more or less at pitch, depending on factors such as the acoustics and the temperatures that they are playing in.

### **Complete spectral breakdown**

Each of my multiphonic notations has been broken down into all audible frequencies. A few composers, especially those in the electroacoustic field, have requested that each multiphonic shows a complete spectral breakdown. To avoid confusion for both composers and performers, it is important that primarily only the most audible frequencies are notated. For reasons discussed earlier in the chapter, for a performer to play the multiphonic accurately, the final notation must not highlight frequencies higher than the highest pitched or the highest most prominent frequency in the notation.

For this particular area of research, I broke down and did a complete spectral analysis of all frequencies within a certain decibel reading; however, many such frequencies are inaudible to the human ear, and so for practicality I chose not to add these to my final charts. It is also important that composers realise that different players and different makes of instruments, mouthpieces and reeds, and changes in acoustics may result in slight variations in some frequencies when different spectra may possibly be audible or inaudible. The results in my charts are those that worked for me in the particular situation I was recording and playing in.

As my final results also contain audio samples that can be extracted for composers to use, it will be easy for composers who wish to have more detail to feed my recordings into spectral software themselves if this is an integral part of any compositional process for them.

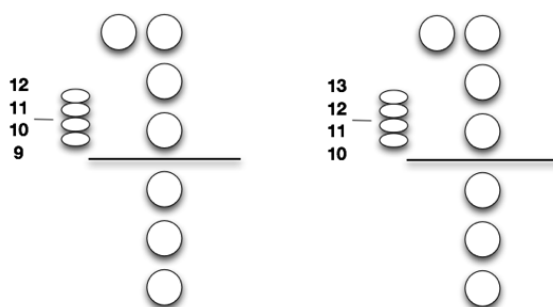
## Trills and tremolos

Many composers have asked for a list of trills and tremolos that will work with each multiphonic. Due to the endless possibilities, I have chosen not to include this in this research. Multiphonic trills and tremolos work very effectively as long as the change between fingerings is logical. Generally, a trill or a tremolo will work when there is just a simple one-finger change. This is an area of composition that really benefits from composer and performer collaboration. Trills and tremolos have been used very effectively in several of the études and pieces written using my new charts. They have been the result of composers asking for advice on certain fingerings to ensure they work successfully.

## Finger charts

One vital aspect of compiling the new set of charts is the fingering systems, as it is very important that players can look at the fingering and know exactly which keys to press for each multiphonic. There are already several different systems for fingering guides, and often there can be a crossover with numbering systems between charts that can cause confusion when trying to decipher which keys are associated with which numbers. An example of this is the four side trill keys, which are sometimes labelled as 9, 10, 11 and 12 and sometimes as 10, 11, 12 and 13, as shown in Fig. 4.1.

**Figure 4.1: Example of side key finger-numbering systems**

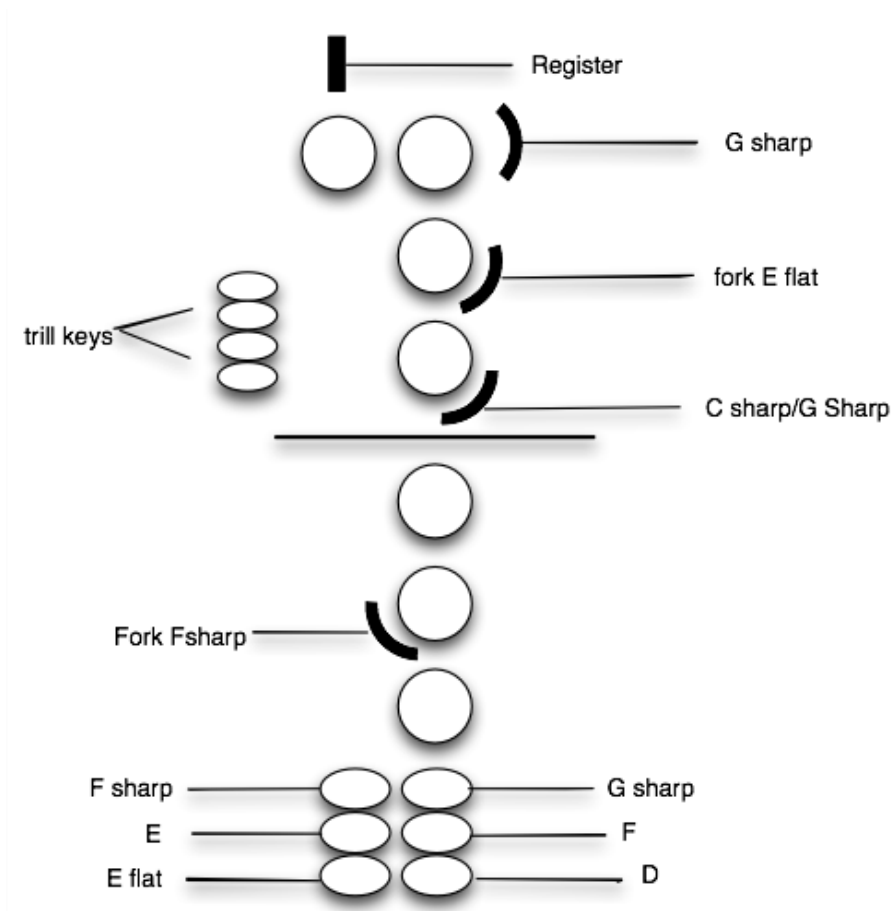


The same can also happen with the little finger keys for both hands and the low note thumb keys. To eliminate further confusion in the future, I have omitted all numeric systems and have solely concentrated on graphic diagrams to show each fingering. Even though fingering systems between different models and makes of bass clarinet are more uniform now, the fingering systems for the little finger keys and the thumb keys on older models have differed in the past. My charts have been tested primarily on Buffet and Selmer models of bass clarinet, and the multiphonics selected work on both models and are accurate. Multiphonics that differed in terms of either the fundamental or the highest audible top notes have not been included in the main set of Type Two charts. The fingering system is based around these two models, in which the key fingering systems are the same.

I have also tested every multiphonic in the charts on several makes of older Selmer model bass clarinets. On certain models, the right-hand thumb key and the right-hand little finger keys that operate the lowest tones controlled by these fingers are different to those on the current models. If a player finds the name of the key that should be pressed according to my charts and presses this key on their bass clarinet, then the multiphonics should work on the older models as well.

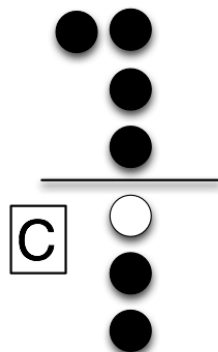
Composers should be encouraged to include the fingering chart indicated in performance instructions and to use the exact diagrams presented next to the multiphonic notations to ensure that there is no confusion for players. Figure 4.2 shows the proposed fingering system. The white keys are coloured black when they need to be pressed and current black keys below are omitted from diagrams if they are not needed for a particular multiphonic.

**Figure 4.2: Fingering system for SW charts**



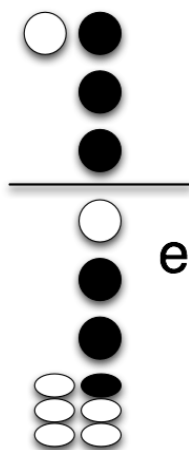
Multiphonics that use the lowest C and C sharp keys have the letter names in boxes to the left-hand side of the diagram as shown in Fig. 4.3.

**Figure 4.3: Use of the low C key**



Multiphonics that occasionally use left-hand little finger keys have the letter of the note written on the right-hand side of the diagram, as seen in Fig. 4.4

**Figure 4.4: Use of left-hand little finger keys**



Composers are advised to only use notations and fingerings. It is not advised to use any numbering system associated with my multiphonic charts, e.g. SW1 or SW195. This is because it should not be expected that every player will have access to my charts even once they are fully published and made easily available. This has been an issue in the past, when, for example, a piece of bass clarinet music simply has a number and no fingering or reference to which resource it has come from. Other problems include multiphonics being listed with reference to a page number which has proved impossible to find when the book in question has gone through revised editions. I also fully expect my multiphonic charts to be edited, amended and revised as time goes on and as more people use them and provide feedback on possible additions. The first draft of charts sent to students and the first complete draft of charts sent to composers to compose études are already out of date as minor revisions have been needed, and therefore the numbering system is subject to changes. Simple fingering and correct notation in the score will mean

that future editions will not cause problems for performers who are trying to translate composers' intentions.

### **The analysis of Type Two multiphonics and the creation of the SW system**

This rest of this chapter looks at the decisions that were made about which factors and features of each multiphonic to include and which to leave out of the final SW charts and also how I came to the decision about what was to be included in the final notations for each multiphonic.

To demonstrate how a Type Two multiphonic fingering is created and why it is special fingerings and not standard, see Figs. 4.5 and 4.6. Figure 4.5 shows standard fingering for a low note G. When the E flat side key is added in Fig. 4.6, a multiphonic is formed. Figure 4.7 shows how taking the thumb away from the standard G fingering produces a different multiphonic.

**Figure 4.5: A standard low G fingering**



**Figure 4.6: The addition of an E flat key creates a multiphonic**





**Figure 4.7: Results with low G fingering minus the thumb**



Type Two multiphonics vary hugely in timbre between fingerings, with some offering many different audible frequencies per multiphonic and some having only have two audible frequencies and appearing to the human ear as a dyad. The frequencies in a Type Two multiphonic vary in audibility. Unlike, for example, a piano chord, in which all the notes of the chord are equal in volume, the partials in a Type Two multiphonic vary in dynamic and timbre. Whilst with some multiphonics a performer can control the overall dynamic (some multiphonics can be played at dynamic levels pp - ff, whilst others can only be played at pp - p), the audibility of partials in each multiphonic are largely uncontrollable. One must also take into consideration other important influences that affect multiphonic production.

Chapter two has looked at feedback from composers and performers - all of whom have talked about the complicated nature of multiphonics. Harry Sparnaay and Henri Bok have both spoken about how individual instruments, mouthpieces and reeds can affect multiphonics even before we consider the effects that performance spaces, acoustics, temperature and atmospheric can have on a particular multiphonic on a particular day.

To help to show a composer how each multiphonic is built up, which partials are the most important and the variation in the audibility of partials, I have devised a chart that places partials into three different categories as well as offering composers two different notation options. See Fig. 4.11 for an example. Whilst I am confident that the important partials are correct in my charts and that those seen in column A (see Fig. 4.11) are stable, it is

important to observe that composers should always expect and be willing to accept a degree of flexibility in performance and recording from player to player and from venue to venue.

As I started to explore and analyse multiphonics and to compare my analysis to past attempts at charting multiphonics, it quickly became apparent that an incorrect notation can often render a multiphonic impossible to play. The best way of explaining why this happens is to compare the bass clarinet to any brass instrument. Effectively, when playing a multiphonic, a performer needs to develop and execute a similar technique to that of a brass player in terms of hearing the sound of the multiphonic or the top most audible note of the multiphonic and then placing the embouchure in such a way that the note is effectively pitched before it is played. An incorrect placing of the embouchure will split a note on a brass instrument. An incorrect placing of the embouchure on a bass clarinet will result in a squeak, the note sounding as a dull low frequency or, with some multiphonics, nothing happening at all.

Often, in charts, high frequencies are notated, even if the high frequency isn't the most audible of the higher notes. When a chart is notated in this way, a player will often incorrectly pitch and play the multiphonic, which results in many cases in the multiphonic not sounding, squeaking or being unstable. When playing a multiphonic on a bass clarinet, the player has to negotiate their way around the natural harmonics of the instrument. Most of the high notes and standard high note fingerings of the bass clarinet from the fourth C and above are simply fingerings that make the best use of the harmonics of the instrument. This effectively relates how we play to how a brass player would play. If a bass clarinetist has to play a multiphonic with, for example, a fourth octave G as the most audible high frequency, then to execute the multiphonic correctly the player must pitch the

G by ear and prepare to play a G in order for the multiphonic to sound. If, for example, a high B flat is written instead, even though it may be audible, as it is not the strongest high partial, if this note is pitched then the multiphonic will not work as it should and will probably split. If one compares this to a brass player splitting a note due to mispitching, then we can see the direct relationship between the two instruments and that both are playing around with harmonics and the harmonic series.

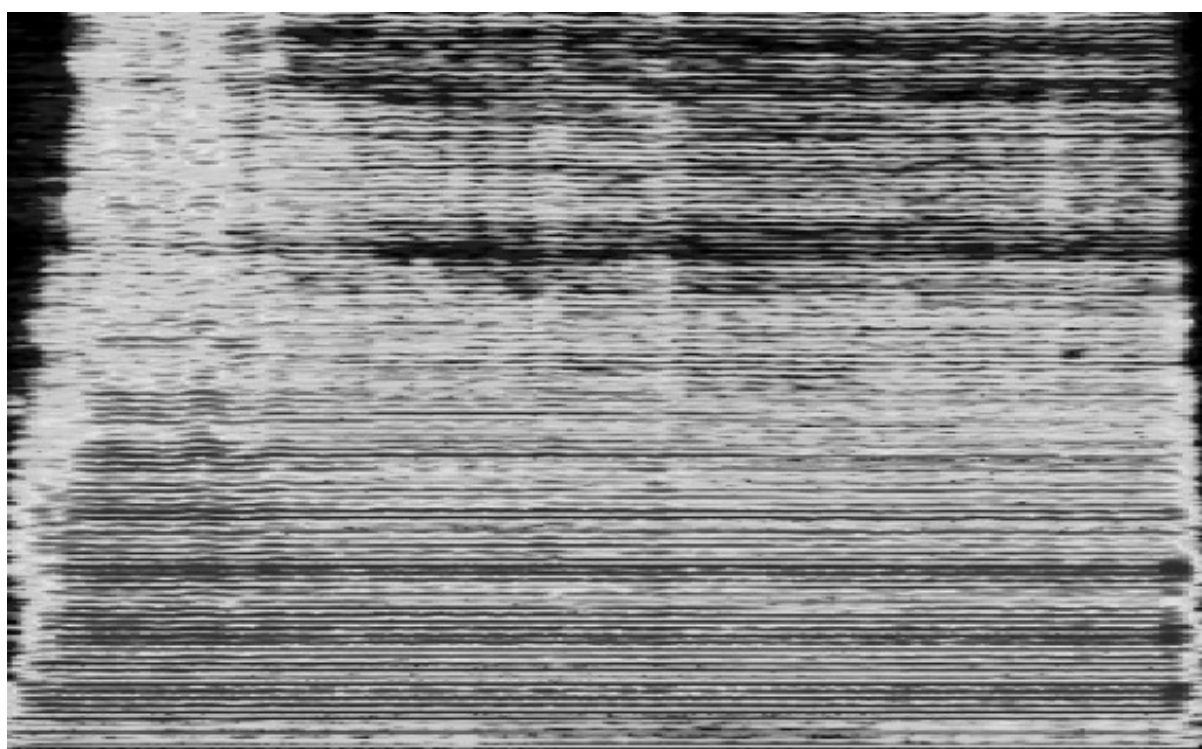
When analysing existing charts it was important to disregard any previous notations. The first step was to analyse the strongest partials aurally (the fundamental and the highest most audible), to learn how to prepare and place the embouchure for each one and where to pitch each one so that they would work. This means that each multiphonic has been reconstructed by learning, first of all, how to play each of them and then finding which notes were the most important to pitch in order for them to work. This confirmed my early suspicions that some charts do contain transposition and notation errors and that, in some cases, both the fundamental low note and higher notes were incorrectly notated. In first attempts at trying the fingerings, I ended up not being able to play a quite a large percentage of existing notations clearly. Once I had discovered exactly which notes were important, however, and had created a two-note chord of the fundamental and the top note, I only found a couple of existing multiphonics that became truly impossible to play. I also discovered that by affecting the embouchure for some multiphonics I could play two multiphonic variants with one fingering (which is similar to how Type One multiphonics work). When I looked at existing charts, I found very little reference to multiphonics that can sound in two different ways with one fingering, except for a few in Harry Sparnaay's charts<sup>72</sup>. I have split my multiphonic charts into two sections to show this: a/ multiphonics with one variant (see Fig. 4.16) and b/ multiphonics with two variants (see Fig. 4.17).

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<sup>72</sup> Harry Sparnaay. *The Bass Clarinet: A Personal History*, Barcelona: Periferia Music, 2011.

Once all the multiphonics had been roughly notated into a two-note dyad by ear and could be easily executed, they were all recorded to *Audiosculpt* for spectral analysis. When analysing Type Two multiphonics using *Audiosculpt*, it is visually very apparent that they are very different in terms of how they are produced and how the frequencies are built up in comparison to a Type One multiphonic. See Figs. 4.8 and 4.9 for a visual comparison. A Type Two multiphonic generally features less frequencies and not as many audible frequencies compared with a Type One multiphonic. Whereas a Type One multiphonic is built up of partials around a harmonic series and can sound quite harsh and full of frequencies, a Type Two multiphonic can often vary in terms of timbre. Some Type Two multiphonics can in fact be very subtle, with only two, three or four very audible frequencies. Even though there are still many partials in each multiphonic, more of them, compared to those in Type One multiphonics, appear inaudible and just affect timbre rather than the audible make-up of the multiphonic. When they are viewed using *Audiosculpt*, it is very clear to see the visual differences between the two.

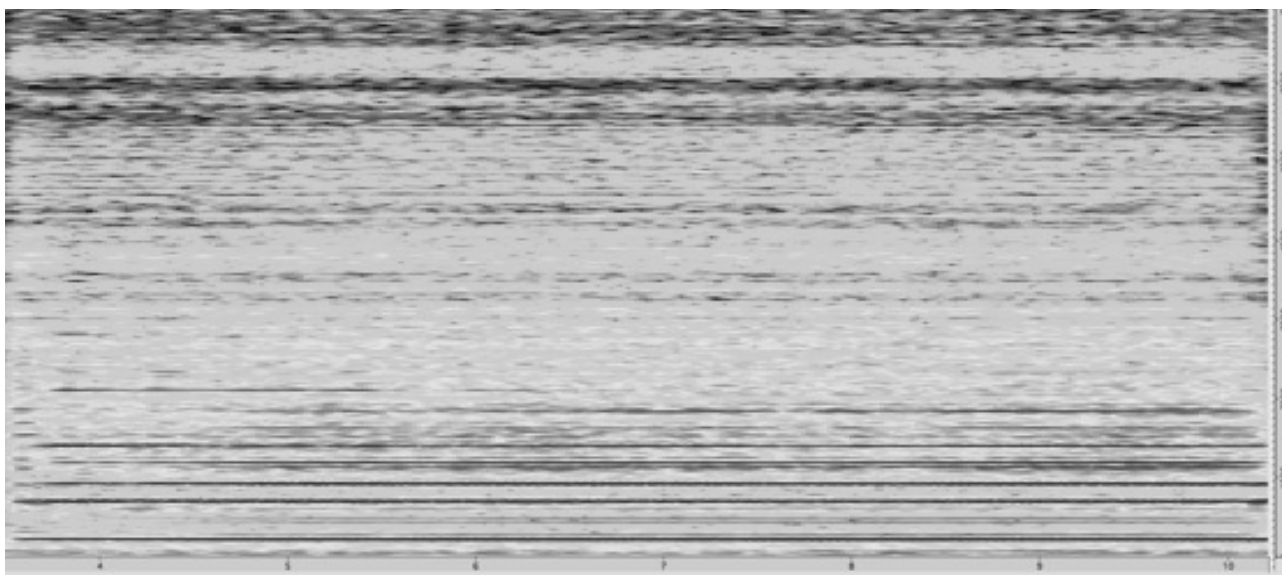
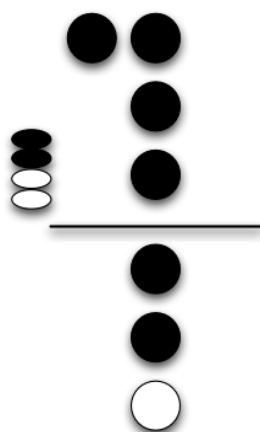
**Figure 4.8: A multiphonic based on a standard fingering low C**



For a breakdown of Fig. 4.8, see chapter three on Type One multiphonics. A complete analysis can be found in Figs. 3.3a to 3.3k.

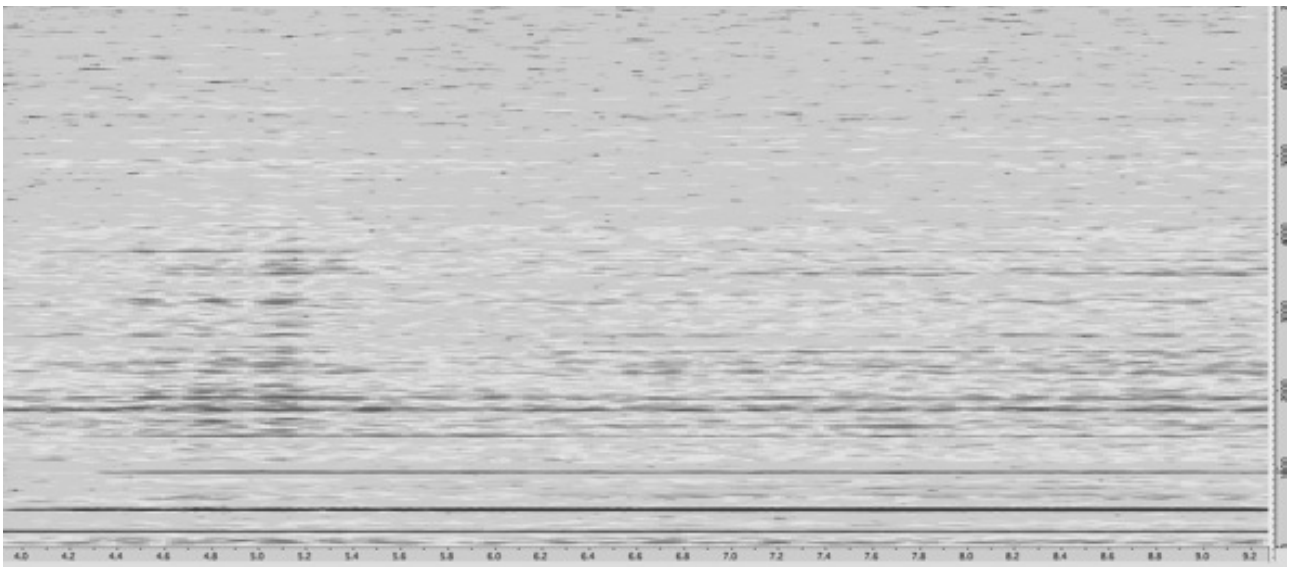
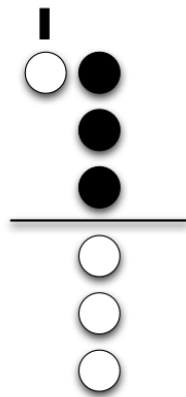
Figures 4.9 and 4.10 show full *Audiosculpt* sonograms for two different Type Two multiphonic fingerings. The complete graphs for both recorded multiphonics are shown, as these also illustrate, at the start of the timeline in Fig. 4.10, that not all multiphonics are able to start with a clean attack. It is also very clear to see visually that the build-up of partials in a Type Two multiphonic is very different and much more sparse than for a Type One multiphonic. Both Fig. 4.9 and Fig. 4.10 show the frequency range from 0Hz to 7000Hz.

**Figure 4.9: An example of a Type Two Multiphonic based on the following fingering**



Some Type Two multiphonics contain even fewer audible frequencies. This again is quite clear to see on the *Audiosculpt* sonogram in Fig. 4.10:

**Figure 4.10: An example of a Type Two multiphonic with less audible frequencies**

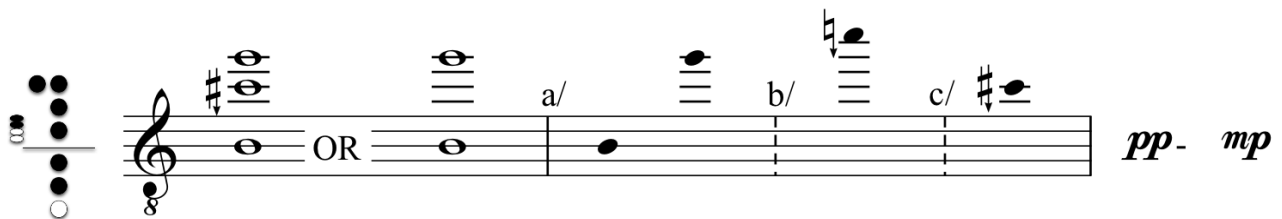


My first step when analysing using *Audiosculpt* was to analyse all partials to the same specifications that were used for the Type One multiphonics. My first step with Type Two multiphonics was to analyse each multiphonic and list frequencies at 0db to -40db so that I could notate the most audible frequencies, as I had done with Type One multiphonics. It became apparent early on in this process, however, that the human ear will often pick up

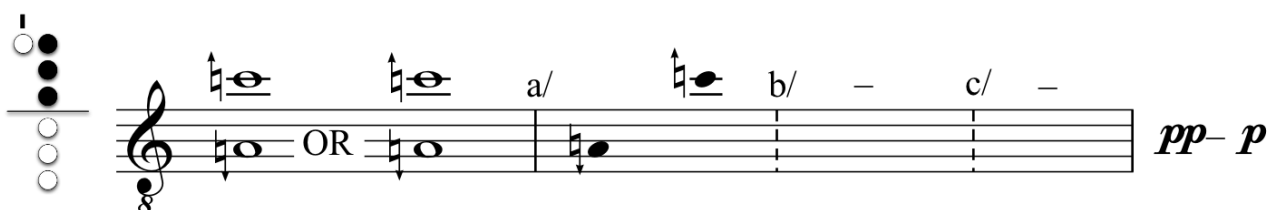
on a frequency that the spectral analysis software declares is not very audible and vice versa. This resulted in an analysis of all frequencies to -60db and then the use of a mixture of *Audiosculpt* results and my ear to create my final charts and the frequencies in each multiphonic.

To explain the build-up of each multiphonic, I notated each multiphonic in two ways that are intended as final notations for the composer. Figure 4.11 shows the results of the multiphonic demonstrated in the *Audiosculpt* sonogram in Fig. 4.9 and shows the final SW notation for this particular multiphonic. Figure 4.12 shows the result for the multiphonic in Fig. 4.10.

**Figure 4.11: Final SW notation of multiphonic from Fig. 4.9**



**Figure 4.12: Final SW notation of multiphonic from Fig. 4.10**



The two chords in the first bar give the composer a notational choice:

- i. a chord with audible partials between the fundamental and the most audible top note; or
- ii. a two-note chord of the fundamental and the most audible top note.

In the case shown in Fig. 4.12 there is no choice of notation so the two chords stay the same. It is important to realise that a higher note above the most audible top note must

never be included in the notation because if this occurs then the multiphonic may not sound at all or as intended.

Each multiphonic was then broken down into three sections that help both a composer and a player to understand how a multiphonic is built up. This part of the guide is intended to be theoretical and not practical. Section A shows the most important and audible partials of the fundamental and the most important and strongest sounding top note.

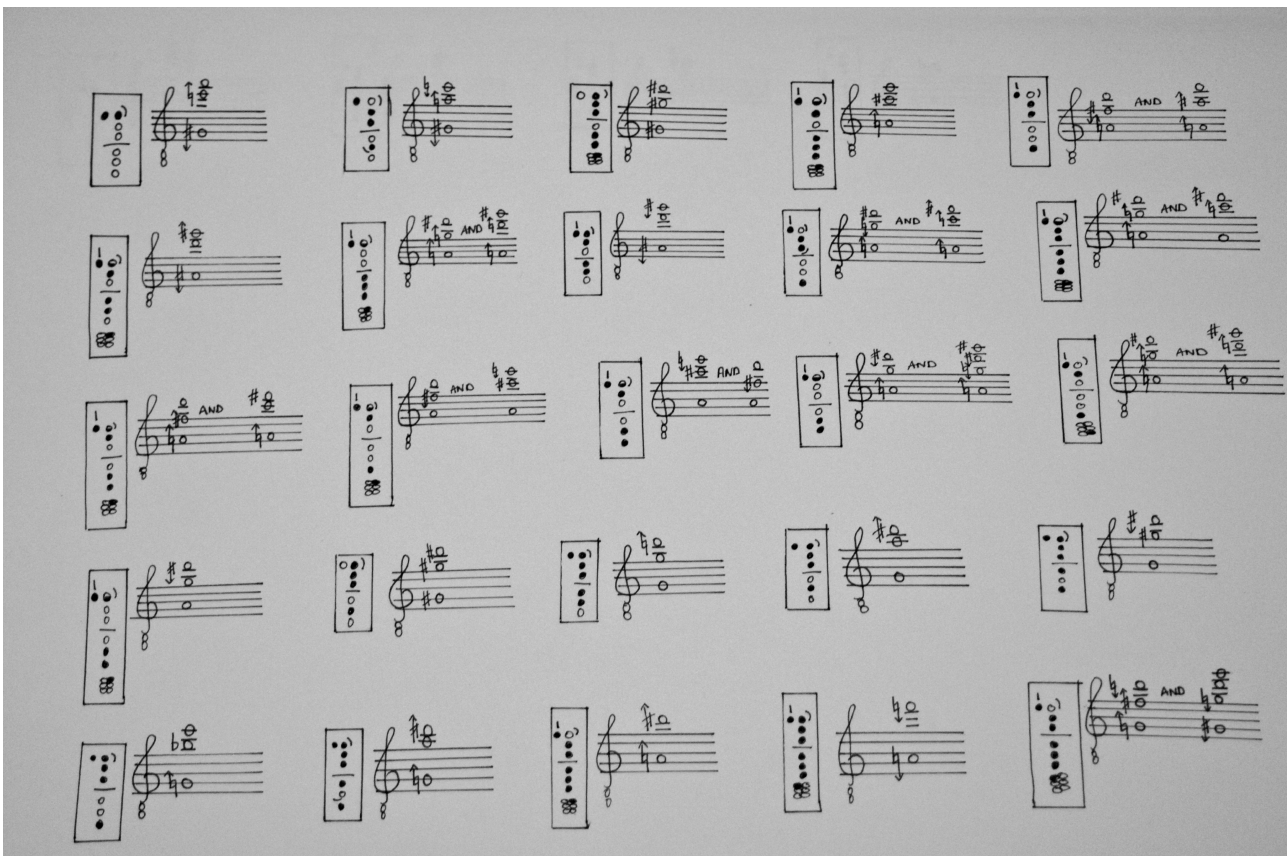
Section B shows other audible partials, but it is important to understand that these may not be as loud in volume as those in section A. Section C shows any other partial that is audible to the human ear. The partials in section C may be very distant and may also, at times, be almost inaudible. They can also be affected strongly by acoustics, the instrument set-up and the characteristics of the player.

The only other information I have chosen to put in the charts is dynamic possibility. This factor is vital, as some multiphonics will only work at certain dynamic levels. If a multiphonic is pushed beyond its dynamic threshold it simply will not sound. It is also important to state that dynamics are relative and should be approached with caution and a flexible attitude. The successful execution of multiphonics is something that is very personal and very dependent upon external factors such as reeds, the weather, the acoustics and the instrument set-up. Giving an indication of stability and embouchure was not very useful and was potentially detrimental for others trying to play the multiphonics. As players, we are capable of finding our own way of producing and executing each multiphonic successfully if the notation and fingering given are reliable. As we all have different set-ups, mouths and teeth alignment, etc., each player will approach the playing of each multiphonic in an individual way that is successful for them. Therefore, it is the notes and the idea of dynamic possibilities that are the important factors.



I have reanalysed all previous charts which I have sourced during this research. The number of multiphonics in these new charts is larger than in any single publication of multiphonics currently available. During the process of analysis, one challenge was to try to order the multiphonics in a way that gave me an indication of possible new fingerings and therefore previously uncharted new multiphonics. All existing multiphonic fingerings that had been reanalysed were noted by finger pattern order into a sketchbook, a sample of which is shown in Fig. 4.13.

**Figure 4.13: Sample of cataloguing by finger system order**



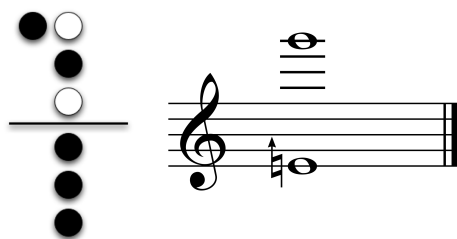
Once fingerings were sketched in this way, it was possible to use the G sharp side key, for example, to search for new fingerings that produced multiphonics that had previously remained uncharted. Throughout this process, it was apparent that there were many gaps

in existing charts and that many new and beautiful fingering combinations and multiphonics could be discovered and charted. As adding a different finger to some made no difference to the sound of some multiphonics (e.g. in some multiphonics changing the right-hand little finger between the six low note keys made a huge change to the multiphonic, but with some multiphonics experimenting in this way made absolutely no change), I made an early decision to only chart new fingerings with obvious changes that could be heard by the human ear. I felt it was important to make this decision so that my final charts stayed practical and useful and were not too large for performers and composers to work with.

### **Methodology:**

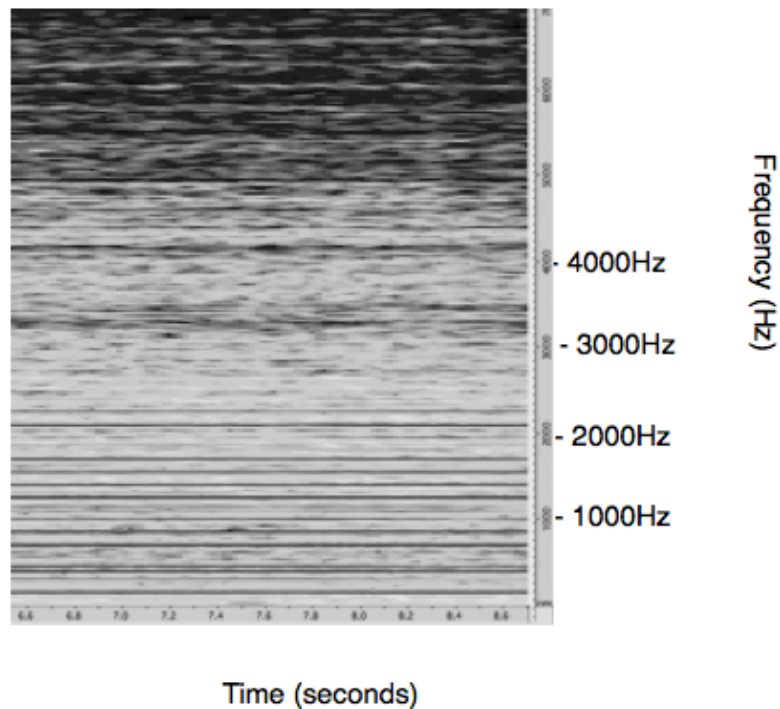
For the analysis of each multiphonic, a step-by-step process was followed. This process remained the same for the whole analysis process. Once my fingering was selected, I played it several times to find out how to play it and how to place my embouchure to get the best-sounding results. I then used my ear to make an initial approximate aural notation of the fundamental and top note that was for me the most prominent. SW31 in Fig. 4.14 is shown as an example:

**Figure 4.14: Example of notation of fundamental and top note's most audible frequency**



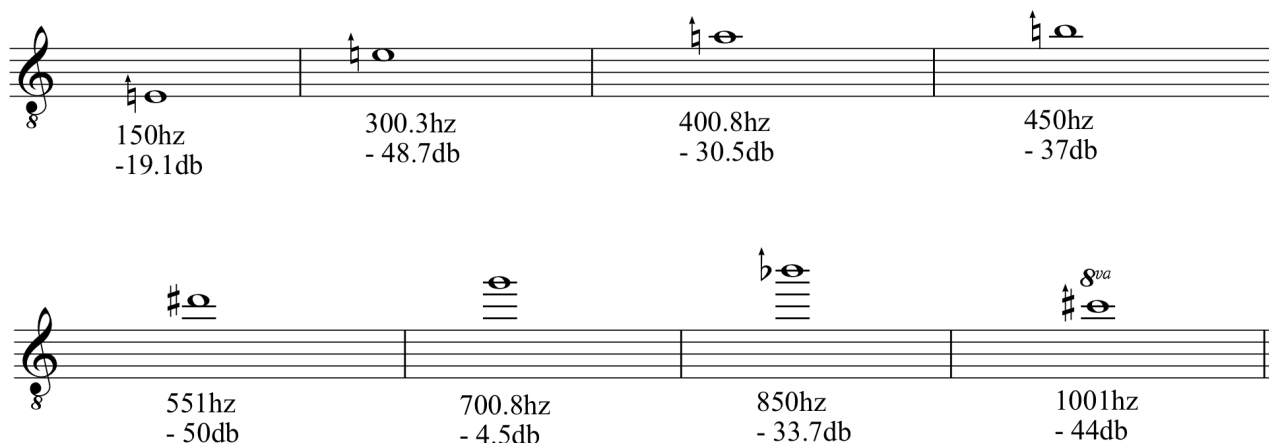
The multiphonic was then entered into *Audiosculpt* and a sonograph was created to the specifications used for Type One analysis. Figure 4.15 shows the sonograph for the multiphonic used in Fig. 4.14. The settings for *Audiosculpt* are the same as the ones used in the chapter three analysis of Type One multiphonics. This used the preset bass clarinet settings, with each spectrogram viewed at an FFT window size of 8192 samples and with the window step at 8x, i.e. the overlap or 'hop' size was 1024 samples.

**Figure 4.15: A sonograph for SW31**



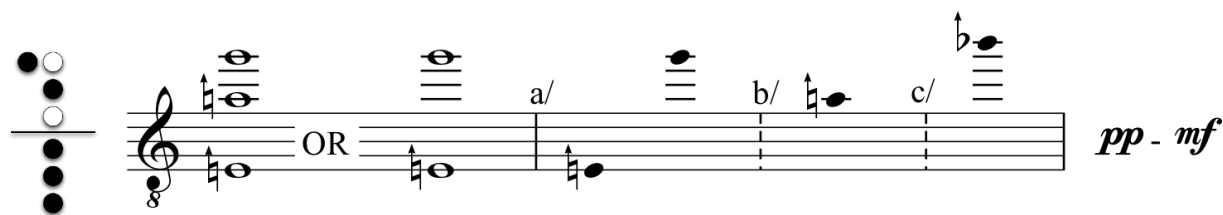
Using *Audiosculpt*, I extracted all frequencies between 0db and -60db that fell within the playable range of the bass clarinet. Figure 4.16 shows this breakdown.

**Figure 4.16: A breakdown of frequencies for SW31**



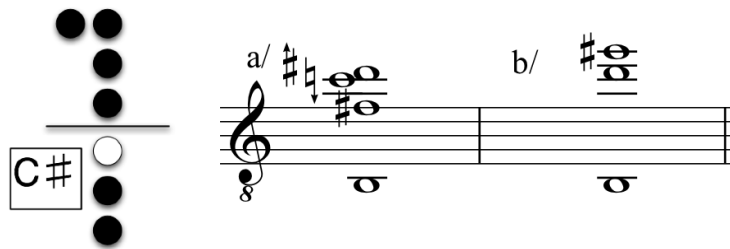
The next step was to use my ear in addition to the above results to compile my final charts for this multiphonic. The final results are broken down into sections of audibility and prominence and fingerings, notations and dynamics are shown. Figure. 4.17 shows the final notation for SW31.

**Figure 4.17: Final notation for SW31**



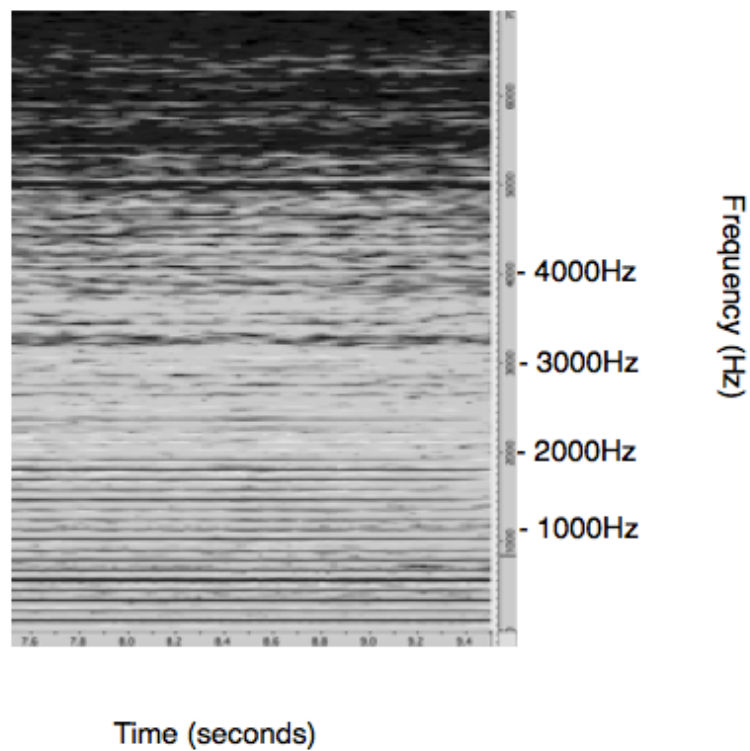
In many cases, it is possible to manipulate the embouchure and create two separate and different multiphonics per fingering. Figure 4.18 shows an example of a multiphonic which is labelled as a Type Two multiphonic with two variants.

**Figure 4.18: A multiphonic with two possible notations**

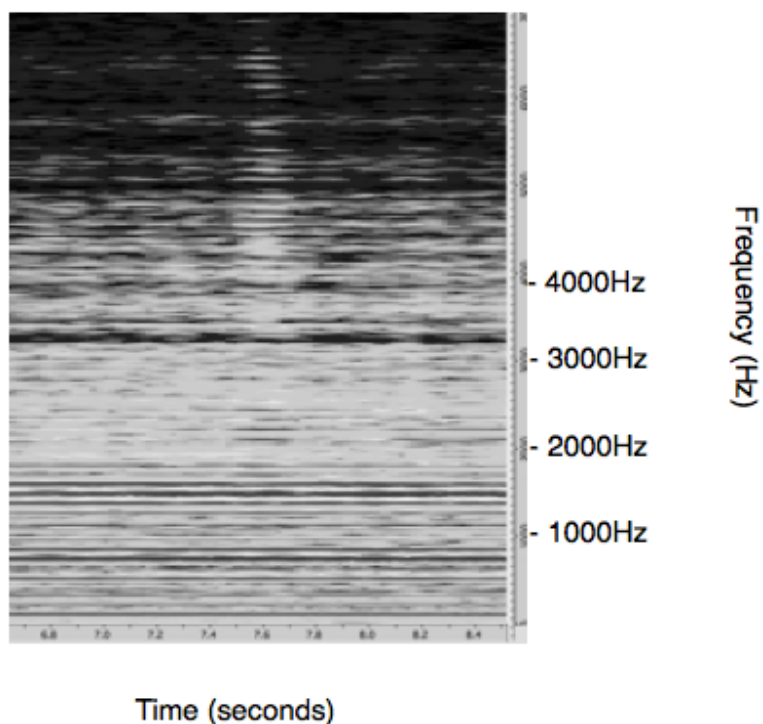


When compared using *Audiosculpt*, the differences between the two variants are very clear to see:

**Figure 4.19: Audiosculpt analysis of Fig. 4.18, variant A**

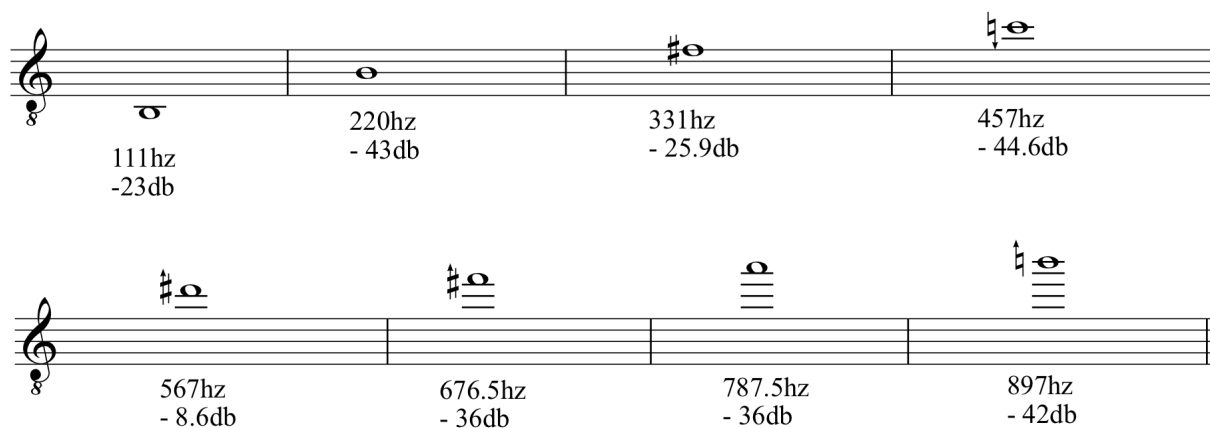


**Figure 4.20: Audiosculpt analysis of Fig. 4.18, variant B**



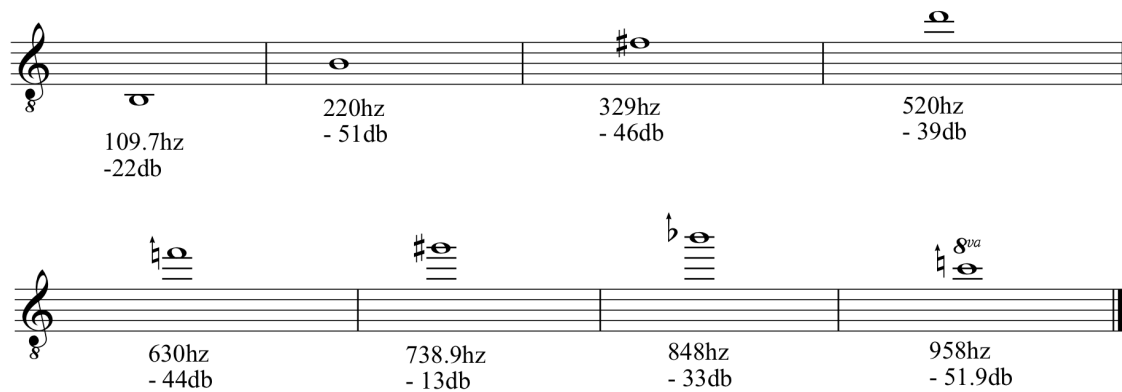
The complete breakdown of variant A from 0 to -60db within the playable range of the bass clarinet is seen in Fig. 4.21:

**Figure 4.21: A complete theoretical breakdown of Fig. 4.19**



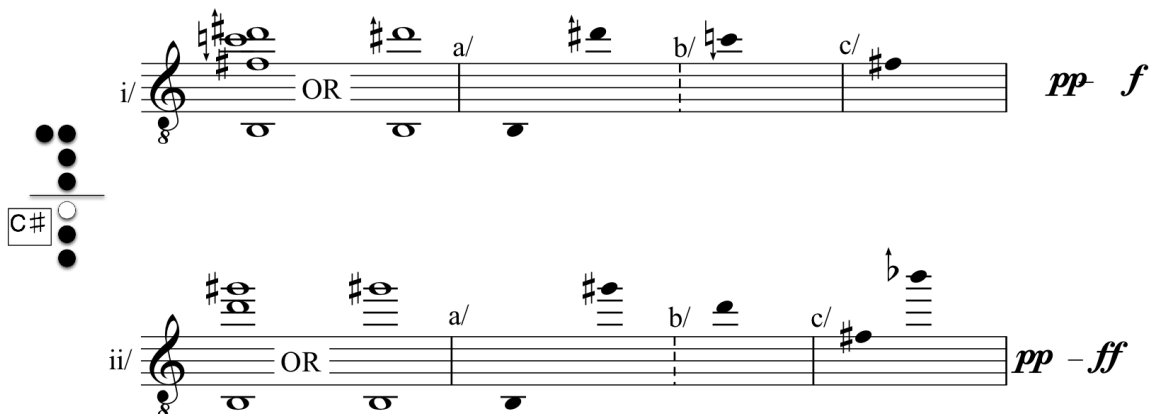
The complete breakdown of Variant B from 0 - -60db within the playable range of the bass clarinet is seen in Fig. 4.22.

**Figure 4.22: A complete theoretical breakdown of Fig.4.19**



From the full analysis, it can be noted that in this case the fundamental B and the octave above stay the same and have only very minute changes in pitch and dynamics. Changing the embouchure drastically, however, alters the rest of the build-up of the multiphonic. The third partial of F sharp stays the same, but we see the decibel level reduce significantly according to the sonogram analysis on variant B. From the fourth partial upwards, many different features can be seen in the different variants. The final analysis of both variants, which is done using the charts and aurally using the charts as support is seen in Fig. 4.23.

**Figure 4.23: The final notations from Figs. 4.18 to 4.22**



The final results confirm that by changing the embouchure and pitching the top notes differently via this embouchure change, it is possible to play two totally different multiphonics using the same fingering.

At present, the decision I have made is to limit the information given for each multiphonic to that given in a final breakdown of

a/ fingering

b/ two choices of notation

c/ practical breakdown of A, B and C sections in terms of levels of audibility

d/ indication of dynamic possibility.

The complete set of SW charts can be seen in Appendix 1, and the next chapter concentrates on the use of the new SW charts in practice.



## Chapter 5

### Multiphonics in practice

#### The use of the SW charts in existing pieces and student test pieces

It has been apparent that there are problems and obstacles in the area of multiphonics that have affected the success of some pieces from both a composer and a performer perspective. One problem is when transpositional and incorrectly analysed multiphonics create major harmonic problems in a piece of music. The harmonic element of many works has been compromised due to inaccurate and untransposed charts. One result of this research is that the SW charts can also be used to rewrite and correct older works. Sections in past works that it was not possible to play accurately due to errors in charts can now, in collaboration with composers, be rectified.

*Vox*<sup>73</sup>, by the British composer Marc Yeats, was composed in 2001 whilst I was studying with Henri Bok at the Rotterdam Conservatory. There are three areas of multiphonic usage within *Vox* that required reorganising:

1. Two sections that use multiphonics in a slow section of swaying sets of multiphonics
2. Problems relating to harmonics being written in the wrong octave.
3. The final section from rehearsal mark 23 is almost solely made up of multiphonics.

Yeats used the multiphonic charts in Bok's *New Techniques for Bass Clarinet*<sup>74</sup> to help to compose the music.

Like other composers, Yeats assumed that the charts would work accurately, that what is in the book would be created by the performer and that the multiphonics would work as he intended. In reality, not all of the multiphonics in this section worked as indicated in the

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<sup>73</sup> Marc Yeats. *Vox*. Scottish Music Information Centre. 2001, rev. 2012.

<sup>74</sup> Henri Bok. *New Techniques for Bass Clarinet*, original edition, Salabert. 1989.

charts. Due to the problem of page numbers being different in different editions, referring to the charts in *New Techniques for Bass Clarinet* trying to add the fingerings to the music myself also caused confusion. Yeats had noted that the multiphonics were in the key of C and not the key of B flat; however, the fact that they were at sounding pitch and not at written pitch was missed, which is a mistake often made by other composers in other works.

After approaching Bok for help and advice about solving this issue, he simply rewrote different fingerings into the music. This was not consistent with what the composer had intended and appeared not to take into account anything in relation to the composer's original harmonic requirements.

These fingerings never worked on my bass clarinet. They did not appear in the *New Techniques* resource, nor do they appear in the new SW charts or in any other existing charts. For some multiphonics, I simply opted for a Type One multiphonic around the fundamental note. Thus, all harmonic and compositional ideas that the composer had intended appeared to be disregarded. In the final passage of *Vox*, the reality of effectively making up the final page of music, thus disregarding a composer's harmonic intention, is surely disrespectful towards both the composer and the piece. From 2001, I found this was happening more often in pieces that include multiphonics. I and other performers were simply not trying to find accurate solutions to multiphonics that didn't sound as written. Indirectly, a situation began to emerge in which performers were trying to dissuade composers from using what is a very effective and colourful compositional technique. The SW charts have given me the ability to work with the composer to reconstruct the passage in question in a way that produces the harmonies that were intended, making the piece accurate and correct. The figures below show a breakdown of the three areas that have been corrected. Figure 5.1 shows the original section of bars 62 - 70.

Figure 5.1: Original multiphonic section between rehearsal marks 10 - 11, and 19 - 20

The image shows two staves of musical notation. The first staff begins at rehearsal mark 10 (measure 62) with a *dolce* marking and a *pp* dynamic. It contains a tremolo-type multiphonic section marked with a box containing '5 p70' and the instruction 'molto vibrato'. The notes are grouped in threes, with a '3' written below each group. The second staff begins at rehearsal mark 19 (measure 69) with a *(p)* dynamic. It contains a tremolo-type multiphonic section marked with a box containing '3 p70'. The notes are grouped in fives, sixes, and sevens, with '5', '6', and '7' written below the respective groups. Both staves have a long slur over the multiphonic sections.

A significant problem with the section in Fig. 5.1 is that the above tremolo-type multiphonics do not appear to be present in Bok's self-published version. The Salabert edition is long since out of print and so it becomes difficult to source and cross-reference. As with other multiphonics in *Vox*, Bok put alternative options for me in my score, which never worked properly on my set-up and were certainly far from the composer's intentions. Figure 5.2 shows the final results, in which it can be seen that whilst the fundamentals were kept similar, the rest of the upper partials were required to change. By collaborating with the composer, however, the results, are closer to what was his original intention.

Figure 5.2: Reworked version of Vox

10

*dolce*

*pp* *p* 3 3 3

version i/ii alternate

(*p*) 5 6 7 *ff*

Fig. 5.3 shows the original version for bars 172 - 178 and Fig. 5.4 shows the corrected version.

Figure 5.3: The original version for rehearsal marks 19 - 20

19

2 p70 *molto dolce* 1 p70

172 3 5

3 p70 1 p70 2 p70

176 6 5 *p*

179 3 ca.3"

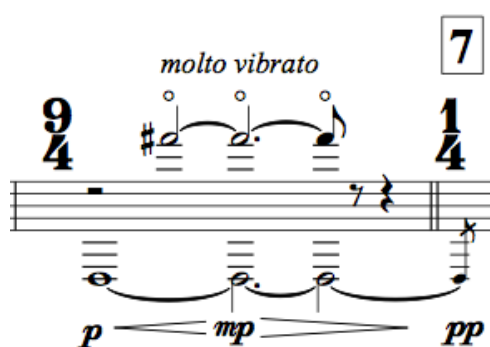
Once again, the same issue arose as in rehearsal number 10 of the above extract, and no fingerings for this appear in the self-published version of Bok’s book. The new version below shows that it was possible to find something very close to how the fundamentals were originally intended, but the upper frequencies of the multiphonics did have to alter to those intended in the original version.

Figure 5.4: Reworked version

Yeats requires the bass clarinetist to play pitched harmonics above standard low note fingerings throughout the piece. In the original version, these were notated an octave too low and would not sound. As seen in chapter three, “Type One multiphonics and spectral analysis”, the note that Yeats required is there within the spectrum of the multiphonic, but only aurally, to a human ear; in addition, because the reed does not allow the note to

appear, it is impossible to produce the original chords that the composer has written. The simplest way of solving this issue, which the composer approved of, was to write the harmonic an octave higher. There are several uses of harmonics within *Vox*. Figure 5.5 shows just one corrected example of a harmonic that Yeats uses in *Vox*:

**Figure 5.5: Between rehearsal marks 6 and 7 – notice that this is the tenth degree of the harmonic series**



3/ The final page of *Vox* was the most problematic section of the music. For this reanalysis, I made the decision not to attempt to analyse or to include the suggested alternatives that Bok wrote in my score. This decision is based on the fact that the fingerings suggested would not work on my bass clarinet and appeared to be very randomly chosen. Instead, I returned to Yeats's original version and attempted to find the original multiphonics from Bok's charts. This was also problematic due to page number differences between the first edition published by Salabert and Bok's own self-published edition. For the first time, using my charts and spectral analysis, it is possible to create a side-by-side view of Bok's notation and actual pitches heard in each multiphonic. Figure 5.6 shows the original final page of *Vox*.

Figure 5.6: The last page of *Vox*, by Marc Yeats – original version

$\text{♩} = \text{ca. } 52$  **meno mosso**

1 p.58 32 p.61

Bass Clarinet in B $\flat$

*mf* *mf*

The multiphonic chords in *New Techniques for the Bass Clarinet* by Henri Bok, are notated at sounding pitch. They are transposed in this score. Chord numbers and the page number of the book are given in the boxes above the chords.

5 30 p.61 1 p.58 3 p.58

*pp* *mf* *p*

10 32 p.61 5 p.58

*f* *ff*

*molto vibrato*

15

*p* *mp* *p* *p*

Figures 5.7, 5.8, 5.9, 5.10 and 5.11 show the breakdown of the comparison between the original Bok multiphonics and the new SW multiphonics. It should be noted that the multiphonic in bar 7 is the same as the one in bar 1 and that the multiphonic in bar 11 is the same as the one in in bar 3 (see Fig. 5.6).

**Figure 5.7: Multiphonic in bar 1**

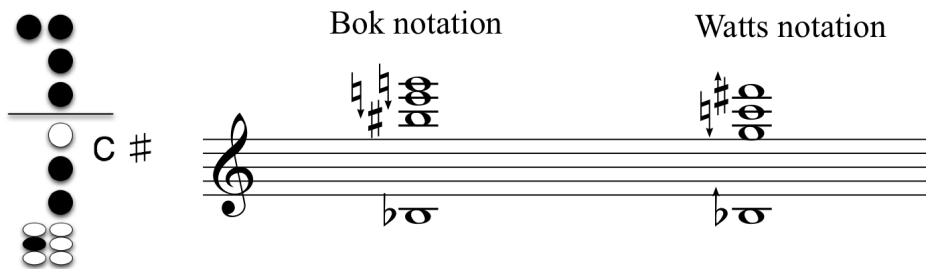
Note that Yeats has transposed all the Bok fingerings which are untransposed in the original Bok charts.

**Figure 5.8: Multiphonic in bar 3**

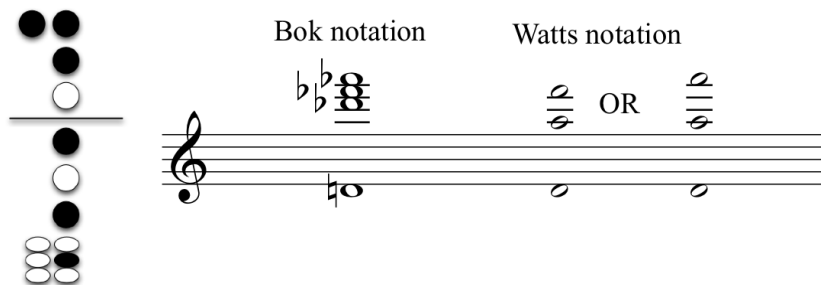
**Figure 5.9: Multiphonic in bar 5**



**Figure 5.10: Multiphonic in bar 9**



**Figure 5.11: Multiphonic in bar 13**



It is quite clearly shown in the above figures that whilst some of the analyses are similar, not one of the multiphonics from Bok's charts is wholly accurate. It should be observed, however, in the cases set out in Figs. 5.8, 5.10 and 5.11 that the fundamental is the same or close to what Yeats wanted. It appears that the fundamental notes in Figs. 5.8 and 5.9 have not been transposed into the correct octave.

There is much inconsistency for the upper partials in most of the multiphonics on this page – some are relatively close, whilst some are incorrect in pitch by more than a semitone in places and, in the case shown in Fig. 5.9, the highest partial is incorrect by more than a tone. It should also be noted that the harmonic above the low C in bar 15 will sound an octave higher than written and, due to this effectively being a Type One multiphonic, may

also feature other frequencies in the harmonic series. See chapter three on Type One multiphonics.

The reorganisation of multiphonics in *Vox* has been done as a performer/composer collaboration with Marc Yeats. This was done in two stages. First of all, it was important to play the original fingerings so that the composer could hear what was actually sounding and compare it to what he intended to hear. The decision was made to completely rework all of the multiphonics in the section and to find multiphonics that were closer to what the composer originally intended. The final version of this section can be seen in Fig. 5.12.

This revised version is now the new official version and was republished by the Scottish Music Information Centre in 2012. The score contains a reference in the performance directions to the fact that this research was used to reconstruct the multiphonic elements of the piece. This means that the new, correct version is available for other players to discover, learn and perform.

Figure 5.12: Final version with new multiphonics from the SW charts

$\text{♩} = \text{ca. } 52$  **meno mosso**

Bass Clarinet in B $\flat$

The score consists of four systems of notation for Bass Clarinet in B $\flat$ . Each system includes a musical staff with a treble clef and a key signature of one flat (B $\flat$ ). The first system is in 4/4 time and features two measures of multiphonics, each marked *mf*. The second system is in 4/4 time and features three measures of multiphonics, marked *pp*, *mf*, and *p* respectively. The third system is in 4/4 time and features two measures of multiphonics, marked *f* and *ff*. The fourth system is in 4/4 time and features a melodic line with a *molto vibrato* marking and a dynamic range from *p* to *mp* to *p*. Fingerings are indicated by black dots for closed fingers and white circles for open fingers. The fingerings for the multiphonics are as follows: System 1: Measure 1 (F $\sharp$ 4, G $\flat$ 4, A $\flat$ 4, B $\flat$ 4, C5, D5, E5, F5), Measure 2 (F $\sharp$ 4, G $\flat$ 4, A $\flat$ 4, B $\flat$ 4, C5, D5, E5, F5); System 2: Measure 1 (F $\sharp$ 4, G $\flat$ 4, A $\flat$ 4, B $\flat$ 4, C5, D5, E5, F5), Measure 2 (F $\sharp$ 4, G $\flat$ 4, A $\flat$ 4, B $\flat$ 4, C5, D5, E5, F5), Measure 3 (F $\sharp$ 4, G $\flat$ 4, A $\flat$ 4, B $\flat$ 4, C5, D5, E5, F5); System 3: Measure 1 (F $\sharp$ 4, G $\flat$ 4, A $\flat$ 4, B $\flat$ 4, C5, D5, E5, F5), Measure 2 (F $\sharp$ 4, G $\flat$ 4, A $\flat$ 4, B $\flat$ 4, C5, D5, E5, F5); System 4: Measure 1 (F $\sharp$ 4, G $\flat$ 4, A $\flat$ 4, B $\flat$ 4, C5, D5, E5, F5), Measure 2 (F $\sharp$ 4, G $\flat$ 4, A $\flat$ 4, B $\flat$ 4, C5, D5, E5, F5).

## **Student test études**

To test the new charts and the effectiveness of my new notation, I undertook several composition projects at the Universities of Keele, Salford, Sheffield and York. These projects took the form of two visits spent working with both undergraduate and postgraduate composition students. The first trip was a lecture presentation of what multiphonics are, my research, my results, and general advice on compositional techniques that can be used within bass clarinet writing and how to write effectively for the bass clarinet. Students were then set a task of writing a short bass clarinet piece for either solo bass clarinet or bass clarinet plus any other combination of instruments, which were which were played in a workshop at a later date.

I did not want to give full access to my charts at this stage, especially since the charts were still at the testing phase. I offered the three universities different sets of selected multiphonics, which consisted of approximately 25 Type Two multiphonics with one variant and 15 Type Two multiphonics with two variants, that used the notations that would make up my final charts later in the research. Also available to the students were instructions for use, a guide to Type One multiphonics and recording samples of the Type Two multiphonics. Students at York University did not use my charts, but did use multiphonics that were found in existing resources.

Figure 5.13 shows an example of a page of my first draft of handwritten student charts. In this case it is a page of Type Two multiphonics with one variant used at Sheffield University:

Figure 5.13: Sample of test SW charts

Sheffield-Type 2- Iversion ③

13 B71 P-F

14 B68 PP-MF

15 B66 P-MF

16 B72 P-F

17 S19 PP-FF

18 S19 PP-F

WOODSTOCK

The students were asked to write a short piece, and no boundaries were given as to the content of the composition other than that it had to contain at least one multiphonic. Across the three universities, the one aspect about the project that caused surprise was the maturity of the student composers when it came to selecting the multiphonics. Rather than smothering pieces with lots of different multiphonics, the majority of the pieces included a small choice of selected multiphonics.

One of the most successful pieces of the testing phase was by a student at Sheffield University. *These Gentle Children*, by Debra Finch, is for bass clarinet and baritone voice. An extract is seen in Fig. 5.14.

**Figure 5.14: Extract from *These Gentle Children*, by Debra Finch**

These Gentle Children Bass Clarinet in B<sup>b</sup> ①

D.A. Finch

Baritone

*Write us.*

*I wrote their names.*

Bass Clarinet in B<sup>b</sup>

*Who are your peo-ple?*

*I asked.*

*We*

*live witha-no-ther whois bad.*

*live witha-no-ther whois bad.*

Handwritten musical score for 'These Gentle Children'. The score is written in 3/8 time and features complex multiphonic notation in both bass and treble clefs. The lyrics are: 'The boy was silent until he knelt before us with a knife...' and 'and squeezed out the blood he cut his own thumb. each other's wounds.' The notation includes various dynamics (mp, mf, f, p) and performance instructions such as 'Expressive' and 'f = c. 76 - more impetus'. The piece is characterized by numerous triplets and slurs, indicating a highly rhythmic and expressive style.

*These Gentle Children* is an excellent example of a good and effective use of multiphonics in a piece of music. The composer understood my notations and took notice of the instructions and advice offered. The multiphonics all have the space and time needed to make them sound and 'speak', and the way in which the piece is composed gives meaning to and justifies the use of this contemporary technique. The music is very clear to read, and the way in which the multiphonics are notated – with simple notation and fingering by the side – means that the performer knows exactly how to play each multiphonic.

One slight problem that has arisen with my test charts is that I have found that instructions are not always read. The more successful pieces that were written using my charts were written by the students who had followed the information given on the information sheet and had then chosen suitable multiphonics for the nature of their writing. The most successful compositions were also those that allowed space and flexibility for multiphonics

to sound and flourish. It was clear that composers who included multiphonics in faster rhythmic passages in a strict metronomic time didn't have as much success as those who gave multiphonic passages more freedom.

On a positive note, other than a couple of minor editorial errors found within my test charts, which we were able to correct or find alternative multiphonics for, the multiphonics written and chosen by composers were accurate and sounded exactly as written in terms of pitch. This testing has shown that two things are essential: first, some sort of dynamic guide for multiphonics should always be supplied and, second, composers should always be aware of any dynamic limitations. A couple of works asked for multiphonics at dynamics that were not possible despite dynamic possibilities being shown in the test charts:

*Sarahphonic* (Fig. 5.15), is an example of why it is essential to follow the basic instructions given within charts and is also a prime example of how choosing to ignore dynamic details can spoil the intention, character and momentum of a piece.

Figure 5.15: Extract from *Sarahphonic*

**Sarahphonic**

Bass Clarinet  
in B $\flat$

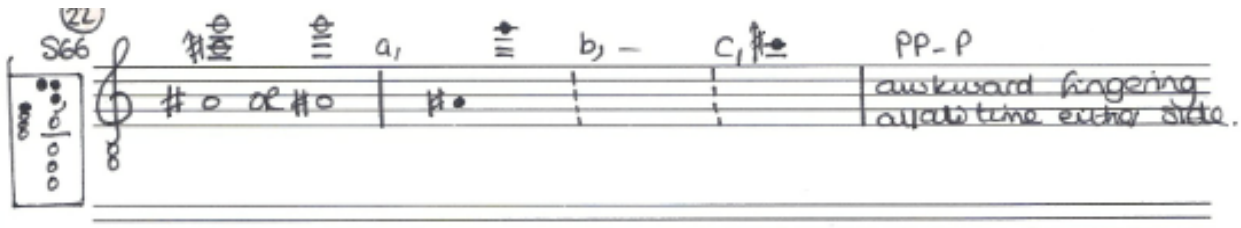
$\text{♩} = 74$

$f$   $mp$   $f$   $mp$   $f$   $mp$

When referring back to the test charts, the dynamic level clearly states that the multiphonic used at the start of *Sarahphonic* will only work at dynamic levels pp – p. See Fig 5.16.



**Figure 5.16: Multiphonic number 1 from *Sarahphonic***



The composer has chosen to ignore this detail, which means that this multiphonic will not sound at the dynamic level indicated as forte in the composition.

From my perspective, I needed to make it very clear to composers that they need to be flexible with a/ dynamics and b/ the time needed for multiphonics to sound and develop. a/ I had to grade the dynamics by volume. I had to make a choice based on how they worked for me after I had played the charts several times using different reeds. The dynamics were also graded by me, and I had to bear in mind that they are a ‘chord’ and not a single note. Often the multiphonics will sound at, for instance, a more extreme level of quiet when marked p and pp. When played loudly, sometimes they can take extra time to settle and feel stable. It is possible that emphasis should be put on composers being more aware of the important fact that not each frequency sounds at the same decibel level. In some works, the multiphonics were chosen and placed by the composers with the intention that they should sound as an equal chord, which, as discussed in earlier chapters, does not happen. More often than not, in some pieces I had to try to force the fundamental to try to play more loudly than it could actually respond to, which rendered some pieces not as successful as others.

b/ I chose not to indicate how long each multiphonic takes to sound and stabilise as I felt that this particular decision would be too personal to my own playing to be accurate across the playing field of other performers. I have also found that different reeds, acoustics, temperatures and venues, etc. make a huge difference to response times. Composers

have to be aware that these aspects may change from day to day and, whilst my notations are as accurate as possible and my dynamics will work if care is taken to observe limits, allowing the flexibility and space for the multiphonics to sound is an important aspect of the compositional and performance process.

The test études are a vital part of this research and helped me to decide, emphasise and justify the decisions made when compiling the SW charts.

A demonstration of another successful test piece is *The Secret*, by Melissa Poon (See Fig. 5.17). Only three multiphonics have been chosen to feature in this composition, and the composer has followed all of my instructions and advice. The multiphonics are notated as two-note chords and a three-note chord, with the fingerings cut and pasted from my test charts directly above each multiphonic. As this is a test piece, the composer has added the numbers of each multiphonic used in my test charts for reference, e.g. B79i, R1.1 and R1.7. These were useful as quick reference points when the piece was played in the workshop. All three of the multiphonics sounded as the composer intended, and she had taken care to observe dynamic markings when choosing them. The multiphonics are also used in a way which allows space for each to sound clearly and for each to develop its full spectra of frequencies. The material surrounding the multiphonics is prepared in a way that blends with the multiphonic and allows preparation time for each multiphonic to be fingered, pitched and executed. The only slight problem was with the use of slap tongue (ST) within a legato phrase, e.g. bar 1, the G, C and D with ST over the notes and bar 3, and the G and D with ST over the top. This is easily resolved by changing the placing of the slurs, and the composer was happy with this suggestion.

Figure 5.17: *The Secret*, by Melissa Poon

**THE SECRET**  
Bass Clarinet in Bb Melissa Poon

Bass Clarinet  $\text{♩} = 118$

B. Cl.  $\text{♩} = 118$

B. Cl.  $\text{♩} = 118$

B. Cl.  $\text{♩} = 118$

B. Cl.  $\text{♩} = 118$

B. Cl.  $\text{♩} = 118$

B. Cl.  $\text{♩} = 118$

COMPOSITION 2 ISP - 2011/2012, © 2012 Melissa Poon

Works composed by students at York University did not use the SW charts. The success rate of multiphonics used in these works was severely diminished compared to the student

pieces that did use the SW charts. Figures. 5.18 to 5.20 show one such work in which the multiphonics used are notated incorrectly:

**Figure 5.18: Excerpt from *IV Four*, by Alex T.Y. Au**

The image shows two staves of musical notation. The top staff starts at measure 36 and ends at measure 39. It features a treble clef, a key signature of one sharp (F#), and a 4/4 time signature. The notation includes triplets, slurs, and dynamic markings of *ff* and *f*. A finger chart for the right hand is shown above the staff, with five fingers indicated by dots. The bottom staff starts at measure 40 and ends at measure 43. It features a treble clef, a key signature of one sharp (F#), and a 4/4 time signature. The notation includes slurs, dynamic markings of *ff*, *f*, and *p*, and a finger chart for the right hand with a G# note indicated above it.

If I analyse the two multiphonics in bars 39 and 40 (Fig 5.19) against my newly analysed charts, we can see that they are inaccurately notated and will not sound as notated.

**Figure 5.19: Analysis of the multiphonic in bars 39 and 40**

The image shows two alternative notations for a multiphonic, labeled 'i/' and 'ii/'. To the left of the staves is a vertical finger chart with five dots: the top dot is black, the second and third are white, the fourth is black, and the fifth is white. A horizontal line is drawn below the first three dots. The 'i/' notation shows a treble clef, a key signature of one sharp (F#), and a 4/4 time signature. It includes a 'g' below the staff, an 'OR' symbol, and three notes labeled 'a/', 'b/', and 'c/'. The dynamic marking is *pp - mp*. The 'ii/' notation shows a treble clef, a key signature of two sharps (F# and C#), and a 4/4 time signature. It includes an 'OR' symbol and three notes labeled 'a/', 'b/', and 'c/'. The dynamic marking is *pp - p*.

The multiphonic in bars 41 and 42 (Fig 5.18 and analysed in Fig. 5.20) is again incorrectly transposed, but this time by about a semitone. There is no G sharp little finger key added in my charts below, as adding this key in this multiphonic made very little difference.

**Figure 5.20: Analysis of the multiphonic in bars 41 and 42**

The figure shows two musical staves in treble clef with a key signature of one sharp (F#). The first staff is labeled 'i/' and the second 'ii/'. Both staves have a dynamic marking of *p - mp*. The notation includes notes with various accidentals and slurs, and a vertical line labeled 'OR' indicating an alternative reading. To the left of the staves is a vertical fingering diagram consisting of a horizontal line with five circles above it: the top two are black, and the bottom three are white.

*Track*, by Chai Jai (Fig 5.21) , contains multiphonics that do not work either notationally or in terms of fingering:

**Figure 5.21: Excerpt from bar 103 of *Track*, by Chai Jai**

The figure shows a musical staff for B. Cl. (Bass Clarinet) starting at measure 103. The notation includes a trill marked 'B tr' and a dynamic marking of *p*. Above the staff is a vertical fingering diagram with five black dots, labeled 'A', 'B tr', and 'F' from top to bottom.

The fingering in Fig 5.21 isn't possible even if I try to press the B trill key, which is the highest of the four side trill keys, with my thumb.

The multiphonic in Fig 5.22 is also impossible to play. This is because it is difficult to decipher the fingering chart as the possible performer interpretations of this chart yield unsuccessful results.

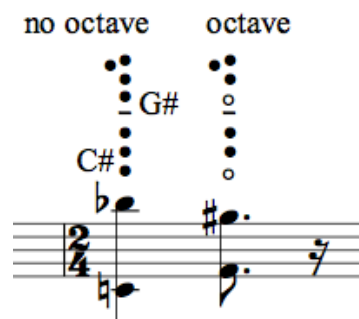
Figure 5.22: Excerpt from bar 35 of *Track*, by Chai Jai



As a performer, I can assume that it is intended that the D sharp be played by using the left-hand fork key between the second and third fingers. But as both of these fingers are being used elsewhere, it is impossible to use this fork key in this instance.

A player can guess that the G sharp should be played by putting the right-hand little finger on the G sharp/D sharp key, but it is not in the correct position on the graphic fingering, which makes it very confusing for a player who is trying to work out which fingers to use. Due to the impossible nature of this fingering, it is not in my multiphonic charts. *Koko*, by Tip Kim Fung, also contains multiphonics (Fig 5.23) which don't work as intended. Neither of the two is used in my final charts because they do not work as viable multiphonics.

Figure 5.23: Extract from *Koko*, by Tip Kim Fung



The three York pieces certainly don't appear to have used existing bass clarinet charts.

The fingerings for *IV Four* (Fig 5.18) are correctly notated in other bass clarinet charts by

Michael E Richards<sup>75</sup>, Rehfeldt<sup>76</sup> and Sparnaay<sup>77</sup>, and I have been unable to locate untransposed versions of these. I am certain that they didn't come from Henri Bok's charts, because they don't feature the numbering system that Bok uses. I can only conclude that these multiphonics must have come from a B flat clarinet multiphonic chart. This is evidence that further education for composers is needed, and it should be made very clear that clarinet charts should not be used as a guide for bass clarinet multiphonics. It is also very clear from all of the student test pieces that specialist bass clarinet charts are very much needed and are really useful. Access to them must be made via a new publication that all performers, composers and institutions can freely obtain in the form of hard copies or by downloading them. Overall, the test pieces of the students were successful. The way in which multiphonics were used as both a musical tool and a compositional tool was impressive, and for the majority of pieces they worked very well.

A surprising fact was that despite no boundaries being set for these studies (it was up to the composer how many multiphonics were used), almost all of the test pieces used only a few well-chosen and well-thought-out selections of multiphonics. The pieces also highlighted the necessity of testing my charts with composers as well as with players due to a number of factors:

a/ Testing via student pieces revealed some minor notational errors in my charts. These errors varied from omitting a key from in the fingering charts to omitting an accidental in the notations. As some differences were fairly subtle and resulted in only slight errors in what I had written compared to how the multiphonics should sound when accurate, they had been missed when testing individual multiphonics from the first draft of charts.

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<sup>75</sup> E Michael Richards. *The Clarinet of the Twenty First Century*, <http://userpages.umbc.edu/~emrich/chapter3-3.html>. 1990-2000.

<sup>76</sup> Phillip Rehfeldt. *New Directions for Clarinet*. Scarecrow Press, 1994, chapter 3 (no page number)

<sup>77</sup> Harry Sparnaay. *The Bass Clarinet: A Personal History*, Periferia Music. 2011. pp. 143 and 144

b/ Initial results using my charts have proved positive. Other than occasional notational and graphical errors in the charts, which I have been able to discover and correct, the multiphonics (both Type One and Type Two) are working and sound as notated when composers observe the instructions offered.

c/ This research is already starting to be justified at this stage. It must be noted that the majority, if not all, of the multiphonics in my charts work for me as intended, analysed and notated. By contrast, many of the York students did not use my samples, but used other resources instead, but it is not possible to play the majority of these multiphonics properly and they do not sound as notated.

d/ It is evident that multiphonics can be used effectively in a number of ways. These pieces have shown that multiphonics can be used as a harmonic and inharmonic tool and to create effects. They can also be used in different styles and genres of music, can have many different timbral qualities and, most importantly, they are an important compositional tool for a contemporary composer.



## Chapter 6

### Composition of études and other new works using the SW charts

There are currently very few technique and method books for bass clarinet. The majority of these, such as *La Clarinette Basse*, by Jean Marc Volta<sup>78</sup>, look at tone production and exercises to aid tone production and technique and are more traditional melodic studies. There is nothing currently available that provides a performer with a method for practising contemporary techniques within the context of a study. Resources about the history of the bass clarinet and playing techniques, such as *New Directions*, by Phillip Rehfeldt<sup>79</sup> *New Techniques for Bass Clarinet*<sup>80</sup> by Henri Bok and *The Bass Clarinet – A Personal History*<sup>81</sup> by Harry Sparnaay list multiphonics and give examples of usage, but there is little in these books by way of advice on how to practise them, nor are there any pieces that can be used to improve technique in this area.

Composers were invited to write a short étude using the SW charts. It is intended that these new pieces will be functional and will appeal to performers as both technical and concert repertoire, thereby giving the composer's composition maximum exposure in a number of situations. The boundaries for the new works were left open. The only restraint advised was to try to keep the piece to about three to four minutes in length, and each piece had to use my multiphonic charts in some way.

The études that have been written are, without exception, highly individual in terms of the ways in which the multiphonics have been used. All of the pieces below have yielded

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<sup>78</sup> Jean Marc Volta. Paris: *The Bass Clarinet Method*, International Music Diffusion. 1996.

<sup>79</sup> Phillip Rehfeldt. *New Directions for Clarinet*, California: University of California Press, 1977, republished by Scarecrow Press. 1994, chapter 3.

<sup>80</sup> Henri Bok. *New Techniques For Bass Clarinet*, Paris: original edition. self published 2004, pp.41-54.

<sup>81</sup> Harry Sparnaay. *The Bass Clarinet: A Personal History*, Barcelona: Periferia Music. 2011, pp. 130-154.

positive results, and any problems that needed to be resolved have been minor; in one or two cases these have highlighted small errors in my charts that have since been corrected and re-notated.

**Marc Yeats – *quarter-Sounds* (CD2, Track 1)**

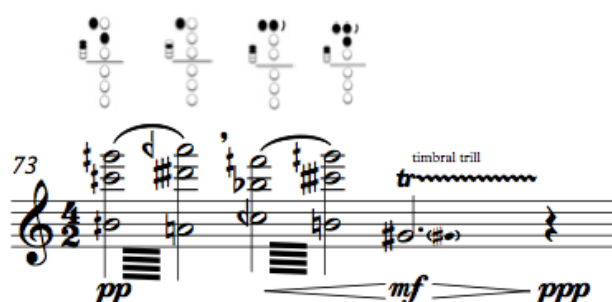
Marc Yeat’s composition *quarter-sounds*<sup>82</sup> is the études, at about 7.5 minutes in length, and is published by the Scottish Music Information Centre. The composer has used a specific selection of multiphonics and has aimed to use multiphonics as a harmonic function. Yeats is very interested in the concept of writing purely multiphonic phrases that each have similar high frequencies, but in which the lower fundamental frequencies have a melodic function. The multiphonics have been chosen with this primarily in mind. Section 5 of the music (Fig 6.1) shows an example of this.

**Figure 6.1: Section 5 of *quarter-sounds*, by Marc Yeats**

<sup>82</sup> Marc Yeats. *quarter-sounds*, Glasgow: Scottish Music Information Centre. 2012.

Despite the fingerings being difficult in bar 48, with a little unconventional and acrobatic use needed of the thumb to active the side trill keys, it is possible to play section 5 from bars 46 to 55, and the fingerings are all very effective and work exactly as notated. The composer has also experimented with multiphonic tremolos. An example in bar 73 (Fig 6.2) shows good and effective use of tremolo multiphonics.

**Figure 6.2: Example of tremolo multiphonics in *quarter-sounds*, by Marc Yeats**



This aspect of the piece highlighted how important composer and performer collaboration is throughout a work such as this. Since unconventional fingerings are used in multiphonics, passages such as the above can become complicated and at times impossible due to the awkwardness and the impracticality of moving between fingerings. Being present to work directly with the composer on this work has resulted in the work still being difficult, but it is rewarding to play it when everything in it is possible. The composer has also gained an understanding about the execution and the potential of the multiphonics and has made allowances for the performance to be musically flexible to allow the multiphonics to respond and for the technical side of them to work.

Yeats also uses multiphonic glissandi to create dramatic effects. This is an effect that he has long used in his bass clarinet writing, including in his first solo work, *Vox*. Section 15 (Fig 6.3) shows two examples of these in bars 96 and 99. Yeats has included references to the harmonic series for these glissandi, which tells the performer that this is indeed a multiphonic glissando. He also notates the glissandi in such a way that it is obvious that he

understands the limits of how far the reed will allow the multiphonic glissandi to take the glissando at both the lower end and the higher end of the multiphonic. We can also see in this section that Yeats uses other Type Two multiphonics in a much more energetic and frantic way. Again, Yeats fully understands the limitations of multiphonics and the instability that they can endure in this type of playing, and he is happy for the tempo to be flexible so that each multiphonic can speak.

**Figure 6.3: Example of multiphonic glissandi in *quarter-sounds*, by Marc Yeats**

The image displays two staves of musical notation for the piece *quarter-sounds* by Marc Yeats. The top staff begins at measure 96 and concludes at measure 111. It features a tempo indication of quarter note = c. 52. The music is characterized by multiphonic glissandi, with dynamic markings ranging from *pp* (pianissimo) to *fff* (fortississimo). Fingering diagrams are provided for several multiphonic passages. The bottom staff starts at measure 98 and ends at measure 104, continuing the multiphonic glissandi with dynamic markings including *f* (forte), *ff* (fortissimo), *p* (piano), and *pp* (pianissimo).

**Iain Matheson – *Geometry of Air* (CD2, Track 2)**

*Geometry of Air*<sup>83</sup>, was one of the first études to be composed for me by the Edinburgh-based composer Iain Matheson. The title refers to the different angles at which the air moves and is guided by the way in which the performer has to manipulate the embouchure and air to produce the multiphonics. The word geometry also reflects the use of special fingerings required to produce each multiphonic. The programme note also indicates that

<sup>83</sup> Ian Matheson. *Geometry of Air*, unpublished. 2012

Matheson has been sensitive to the nature and complexity of using multiphonics within composition.

The piece uses the compositional style of serialism and all the common rules and permutations of a twelve-note row. Twelve multiphonics have been chosen that represent the twelve notes in a chromatic scale. It should be noted that the multiphonics chosen all have a fundamental that isn't naturally sharp or flat in pitch. The twelve multiphonics (in the order they appear) used in *Geometry of Air* are seen in Fig 6.4:

**Figure 6.4: Multiphonics used in *Geometry of Air*, by Iain Matheson**

The figure displays twelve numbered examples of multiphonics, each consisting of a vertical fingering diagram and a corresponding musical staff. The examples are arranged in a 4x3 grid:

- 1/**: Fingering diagram with notes G, A, B, C, D, E, F, G. Musical staff shows a melodic line.
- 2/**: Fingering diagram with notes G, A, B, C, D, E, F, G. Musical staff shows a melodic line.
- 3/**: Fingering diagram with notes G, A, B, C, D, E, F, G. Musical staff shows a note labeled 'M'. Text: "type 1 on overblown normal fingering".
- 4/**: Fingering diagram with notes G, A, B, C, D, E, F, G. Musical staff shows a melodic line with a triplet.
- 5/**: Fingering diagram with notes G, A, B, C, D, E, F, G. Musical staff shows a melodic line.
- 6/**: Fingering diagram with notes G, A, B, C, D, E, F, G. Musical staff shows a melodic line.
- 7/**: Fingering diagram with notes G, A, B, C, D, E, F, G. Musical staff shows a melodic line.
- 8/**: Fingering diagram with notes G, A, B, C, D, E, F, G. Musical staff shows a melodic line.
- 9/**: Fingering diagram with notes G, A, B, C, D, E, F, G. Musical staff shows a melodic line.
- 10/**: Fingering diagram with notes G, A, B, C, D, E, F, G. Musical staff shows a melodic line.
- 11/**: Fingering diagram with notes G, A, B, C, D, E, F, G. Musical staff shows a melodic line.
- 12/**: Fingering diagram with notes G, A, B, C, D, E, F, G. Musical staff shows a melodic line.

The multiphonics build up to the centre of the piece in which a partial ‘series’ of eight multiphonics (Fig 6.5) is heard before disappearing in turn until only single notes are heard again by the end.

**Figure 6.5: Extract from *Geometry of Air*, by Iain Matheson, which uses the eighth tone partial series:**

The image shows a musical score for two staves. The first staff begins at measure 38 and contains a triplet of eighth notes, followed by a series of notes with multiphonic diagrams above them. Dynamics markings include *p*, *f*, *p*, *ff*, and *pp*. The second staff begins at measure 42 and features a series of notes with multiphonic diagrams above them, including a quintuplet of eighth notes. Dynamics markings include *f* and *p*.

When dealing with multiphonics in certain pieces, sometimes a decision is made that a particular one does not react well with a certain part of the music. The second multiphonic with the B fundamental (or number 9) on the previous page was one such multiphonic. As a performer, I felt that the instability of this multiphonic in the setting of this piece was in fact a hindrance, so I made the decision to try to find an alternative to present to the composer as an option. As my charts are extensive, I had a number of options with low B as a fundamental and was able to provide a stable alternative. as a fundamental and was able to provide a stable alternative. See Fig. 6.6:

Figure 6.6: Example of a replacement multiphonic used in *Geometry of Air*, by Iain

Matheson

The image shows two musical staves for a multiphonic in G major. The first staff, labeled 'i/' and marked 'pp', shows a sequence of notes: G#4, A4, B4, C#5, and D5. The second staff, labeled 'ii/' and marked 'ff', shows a sequence: G#4, A4, B4, C#5, and D5 with a flat (Db5). A diagram to the left of the staves shows a C# note with four dots above it, indicating fingerings for the notes in the multiphonic.

The second version of this multiphonic had a similar tonal quality to the original one chosen by the composer, and the composer was happy to replace the original version with this. This is a good example of how composer collaboration and a set of charts with good alternatives have solved a potential performance issue.

**Gareth Churchill – *Airway* (CD2, Track 3)**

*Airway*<sup>84</sup>, by Gareth Churchill, was written as one of a set of *Elemental Studies* for solo wind instruments. The title contains one of the four elements – air – and, like the other pieces, finds its harmonic idiom by musically decoding the element in question. Air has been deciphered by using the letters of the word and solfège to create the harmonic basis of the piece: A = A, (t)i = B and r(e) = D.

Whilst the first half of the title refers to the element, the second half of the title is an abstract or pun on the mechanics of the piece. *Airway* is a reference to the passage of air through the player and their instrument and also through the piece itself.

The multiphonics only appear in the centre of the piece and the composer has taken care to choose only multiphonics that fitted in with the music's harmonic structure. The intention

<sup>84</sup> Gareth Churchill. *Airway*, unpublished. 2012

of choosing multiphonics that audibly avoid inharmonic frequencies is that a microtonal interruption of the pieces 'Airway' is avoided.

**Figure 6.7: Excerpt from *Airway*, by Gareth Churchill**

Meno mosso ♩ = 60

(‘open’ sound to multiphonics)

28 *pesante* *f* *p* *mp* *sonore*

33 *p* *pp* *mf* *ff*

Tempo primo ♩ = c. 63 - 72  
*scorrevole ma misurate*

37 *pp* *mf* *p* *mp*

The image shows three systems of musical notation for B. Cl. with corresponding fingering diagrams. The first system (measures 28-32) is marked 'Meno mosso' with a tempo of 60. It features a 'pesante' section with triplets and a 'sonore' section. Dynamics range from *f* to *mp*. The second system (measures 33-36) starts with a triplet and includes dynamics *p*, *pp*, *mf*, and *ff*. The third system (measures 37-40) is marked 'Tempo primo' with a tempo of approximately 63-72, described as 'scorrevole ma misurate'. It includes triplets and sextuplets with dynamics *pp*, *mf*, *p*, and *mp*. Fingerings are indicated by numbers 1-3 above notes, and diagrams show finger positions on keys.

Figure 6.7 shows the multiphonic section of *Airway*, and it is clear to see that the composer has harmonic intentions for this section. The use of multiphonics and the space created within the music allow the multiphonics to evolve and fade or to continue to grow in such a way that the effect of using them in this étude is very powerful, and, in my view, exquisite.

### **Antony Clare – *Sybil* (CD2, Track 4)**

*Sybil*<sup>85</sup>, by Antony Clare, is another étude that only uses a small selection of multiphonics.

The piece is inspired by a quote from Heraclitus, who was writing in the fifth century BC:

<sup>85</sup> Antony Clare. *Sybil*, unpublished. 2012



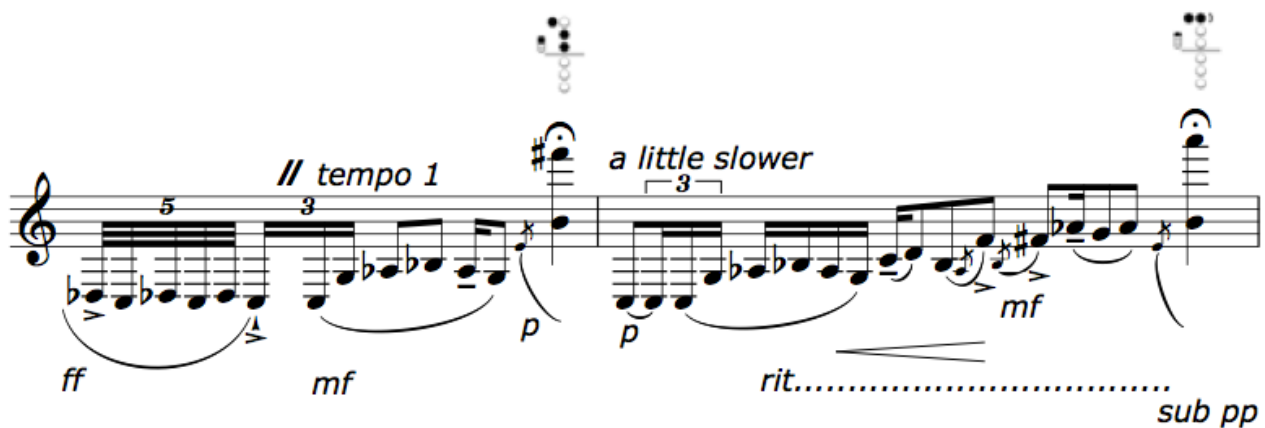
‘The Sibyl [a Greek Prophetess], with frenzied mouth uttering things not to be laughed at, unadorned and unperfumed, yet reaches to a thousand years with her voice.’

The four multiphonics selected were chosen because they use the intervals of a perfect fifth or a minor seventh, which is an integral aspect of the melodic shaping of the piece. The theme of the piece and also these intervals are a feature of the composer’s general compositional style and influences. Therefore, he has used multiphonics within the piece, whilst still using his normative compositional style. The two intervals are seen in Fig 6.8 and Fig 6.9.

Figure 6.8: Excerpt 1 from *Sybil*, by Antony Clare



Figure 6.9: Excerpt 2 from *Sybil*, by Antony Clare

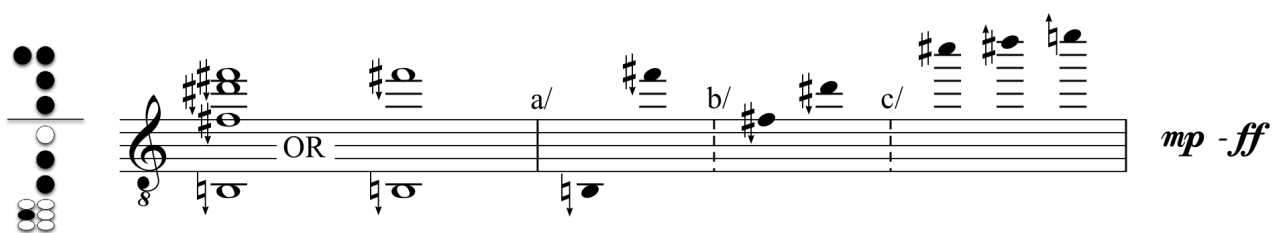


The multiphonics appear at the start of the piece and reappear at the end of the piece. Time and space are allowed so that the multiphonics can be executed and can sound before the performer moves on to other phrases. The centre of the piece is a huge climactic build-up that is devoid of multiphonics, which allows the full force of the single-lined bass clarinet to come through. As with *Geometry of Air*, by Iain Matheson, it was felt that one multiphonic was not as stable as the rest, and for this particular setting the composer and I decided that we should find a multiphonic that would be stable and reliable in performance settings. We replaced the first multiphonic seen in Fig 6.10 with the multiphonic seen in Fig 6.11.

**Figure 6.10: Example of a multiphonic in the first version of *Sybil*, by Antony Clare**



**Figure 6.11: Multiphonic used to replace the original choice in Fig 6.10**



Even though the fundamental and the high F sharp are slightly flat in pitch, the composer felt that this multiphonic was stable and was more suitable for the character needed to project the majestic and dramatic nature of the music.

**Miroslav Spasov – *Mi Cantare!* (CD2, Track 5)**

*Mi cantare!*<sup>86</sup>, by Miroslav Spasov, is one of the more lyrical études written for this research project and is influenced by Macedonian folk melody. A small choice of eight different multiphonics add punctuation to vast melodic lines that use the entire range of the bass clarinet. An extract is seen in Fig. 6.12.

**Figure 6.12: Excerpt from *Mi cantare!*, by Miroslav Spasov**

Mi cantare!  
for Sarah Watts  
for bass clarinet  
Miroslav Spasov

Bass Cl. in Bb

♩ = 96

pp p mp p mp

mf mp mp mp mf

SW5 SW72

10 10

© 2012/13/14

For this draft of the composition, Miroslav Spasov has used my first draft of numbering systems to indicate fingerings. It is important to note that the composer has put a complete set of fingering charts and my notational breakdowns in the introductory programme notes. This is vital for the performer, which was illustrated when an error was discovered during the rehearsal stages of learning the piece in that the multiphonic SW114 appears twice in the piece (in bars 18 and 36) and is notated differently each time. In bar 18 (Fig 6.13) the multiphonic, when attempted, would not sound as notated; bar 36 (Fig. 6.14) worked perfectly, however. Upon checking my notated charts in the programme notes (Fig. 6.15) again, I was able to inform the composer of this small error.

<sup>86</sup> Miroslav Spasov. *Mi cantare!*, unpublished. 2012

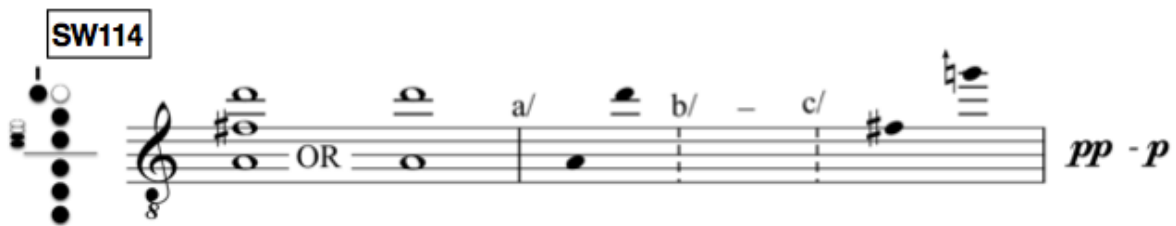
Figure 6.13: Incorrect multiphonic in bar 18



Figure 6.14: Correct multiphonic in bar 36

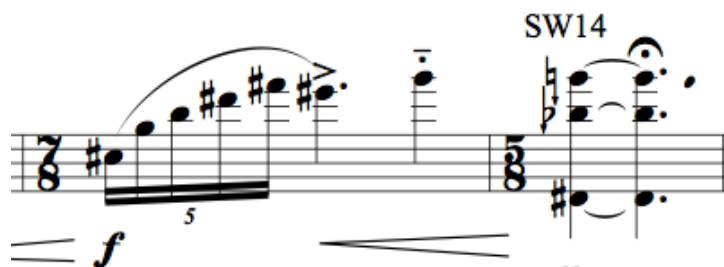


Figure 6.15: Multiphonic taken from SW charts and used in programme notes



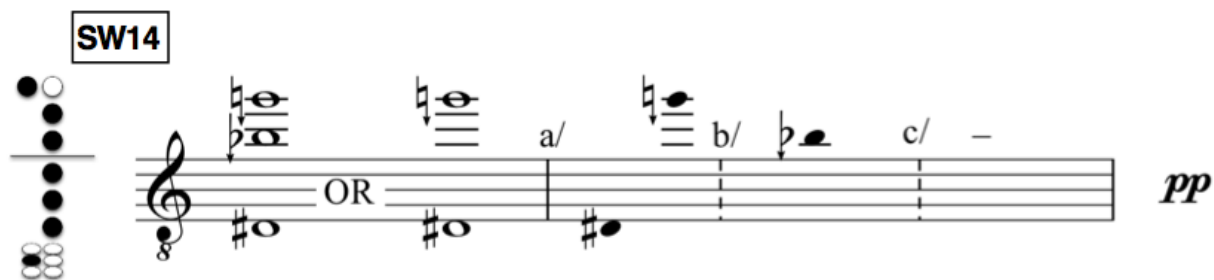
The multiphonic at bar 18 was altered, as shown in Fig 6.16, and the multiphonic immediately sounded as intended by the composer:

Figure: 6.16: Corrected in bar 18



As the composer is making reference to my first draft of charts with the SW numbering system, he has made extensive programme notes and has listed my full breakdown for each multiphonic. The guide for SW14 in the programme notes can be seen in Fig 6.17:

**Figure 6.17: Programme diagram from SW charts for SW14**



This means that any performer can play this piece without needing direct access to my resource as it is clearly notated in detail at the start. This is also a way in which the composer can leave the notation of the multiphonics for the performer to add their own style, which in turn helps to save space and possibly unneeded extra page turns in the copy of a solo piece of music.

The importance of the use of accurate charts was highlighted when I solved this accidental error. With past charts, many players would perhaps have just kept playing with an incorrect multiphonic or would have made up a multiphonic that may not have pleased the composer. The use of accurately notated charts meant that the problem multiphonic was highlighted and resolved quickly and efficiently.

### **Sohrab Uduman - *three days on the road* (CD2, Track 6)**

*three days on the road*<sup>87</sup>, by Sohrab Uduman, shows how my multiphonics can be used without a direct reference to the numbering system in my charts. Twelve multiphonics have been used and are numbered in the score as 1, 2 and 3, etc.

<sup>87</sup> Sohrab Uduman. *three days on the road*, unpublished. 2012



success of a piece in terms of notation and therefore execution with regard to multiphonics.

In the first draft of the piece, the composer had put only the number of the multiphonic, the fingering and the fundamental note. As has happened in other pieces that only have the fundamental note, the first time I attempted to play it I could not pitch and prepare each multiphonic as I did not know where to place my embouchure, so the piece became inaccurate in terms of the multiphonic production. Figure 6.20 is an example of the first draft and Fig. 6.21 is an example of the second draft of a short passage containing multiphonics 5, 6 and 7:

**Figure 6.20: First draft with no chordal notation**

Figure 6.20 shows a musical passage with four notes on a staff. Above the staff, three multiphonic diagrams are shown, labeled (5), (6), and (7). Diagram (5) has a circled 'g#' next to it. Below the staff, the notes are marked with 'M' and a slur covers the first three notes. Dynamics markings are *p* < *mp* for the first two notes, *pp* for the third, and *p* < *f* for the fourth. A '(1)' is written above the fourth note.

**Figure 6.21: Second draft with full chordal notation**

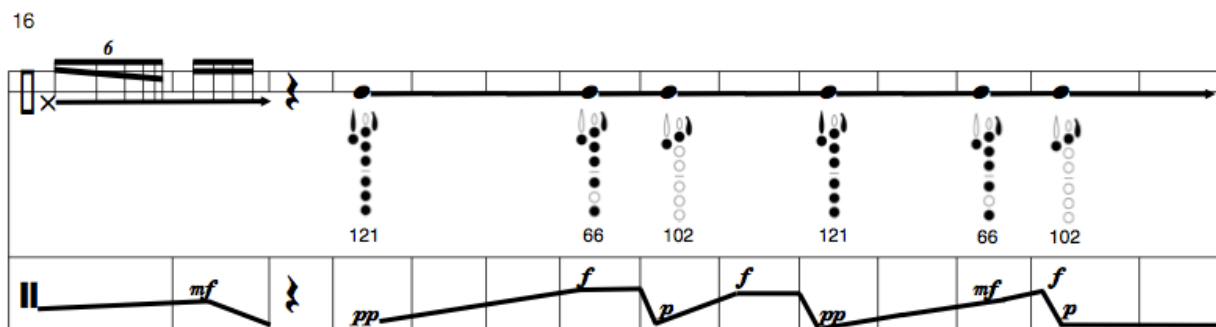
Figure 6.21 shows the same musical passage as Figure 6.20, but with full chordal notation. The notes on the staff are now beamed together and have small circles above them, indicating specific pitches. The multiphonic diagrams (5), (6), and (7) are also present. Dynamics markings are *p* < *mp*, *pp*, and *p* < *f*. A '(1)' is written above the fourth note.

Multiphonic 5 (Fig 6.21) requires the highest frequency to be pitched and played as a G sharp, which will require a very different embouchure to the other multiphonics, which require different variants of a D. Without this notation, the passage is impossible to play correctly because a performer will misplace the embouchure position. The multiphonics in this piece are positioned in a well-thought-out way. In a technically challenging and often fast flowing piece, the multiphonics are written in such a way that they are given space and time to sound and flow, which creates a sense of calm and highlights the faster sections of the music well.

**Victor Beaz – *Multiphonic Study* (CD2, Track 7)**

*Multiphonic Study*<sup>88</sup>, by Victor Beaz is based upon contemporary effects, the majority of which are multiphonics. The score is set out in graphic score notation (see excerpt in Fig. 6.22), with one line being dedicated to the music, an approximate rhythm and notation, and the other line being dedicated to the dynamics, and on occasion the rhythmic dynamics, in a longer note. The fingering for each multiphonic is underneath the graphic notation. The composer has taken care when writing to ensure that fingering works easily when moving from one multiphonic to another.

**Figure 6.22: Excerpt from *Multiphonic Study*, by Victor Beaz**



<sup>88</sup> Victor Baez. *Multiphonic Study*, unpublished. 2012



The same applies to multiphonic trills (Fig 6.23) in which the composer has taken care to ensure that only one finger changes per trill.

**Figure 6.23: Example of multiphonic trills**

Figure 6.23 illustrates a musical score for multiphonic trills. The score is marked with *ff* and includes a dynamic change to *pp*. The notation shows a trill starting on a note with a *ff* dynamic, followed by a trill on a higher note, and then a trill on a lower note. The score is divided into measures, with a *pp* dynamic indicated in the first and last measures. The notation includes a *fff poss.* marking. Below the staff, there are fingerings for the notes: 147, 180 + 182, and 66 + 67. The score is numbered 87.

The composer has also used both variants of some Type Two multiphonics (Fig 6.24). This has been indicated by putting 'i' and 'ii' above the multiphonic being played.

**Figure 6.24: Example of using both variants in some Type Two multiphonics**

Figure 6.24 illustrates a musical score for Type Two multiphonics. The score is marked with *pp*, *mp*, *pp*, *pp*, *mf*, *p*, *ff*, and *p*. The notation shows a multiphonic starting on a note with a *pp* dynamic, followed by a multiphonic on a higher note, and then a multiphonic on a lower note. The score is divided into measures, with a *pp* dynamic indicated in the first and last measures. The notation includes a *ff* marking. Below the staff, there are fingerings for the notes: 182, 62, 214, and 142 + 147. The score is numbered 138.

In the first draft of this study, the composer has entered each number from the first draft of my final charts for each fingering. For the reasons discussed in earlier chapters, a performer needs to know exactly which notes to play in order to execute each multiphonic correctly, so I have encouraged the composer to put the fingerings with notations in the

programme notes. This will ensure that a performer can prepare and learn the piece accurately and having the notation in the programme notes will therefore not affect the appearance of the graphic score. I have also encouraged the composer to remove the numbers that refer to each multiphonic. These numbers relate to my first draft of final charts and, following proofreading and working with the composers, there are already minor amendments and the numbers will be different in later drafts. It is important that whilst others realise that although my charts are used in this piece, using the numbers may be problematic for two reasons: 1/ as my charts are updated and possibly added to in the future, the numbering system may alter and 2/ although of course I would like the publication to be available to as wide an audience as possible, it is important not to assume that everybody has the charts to refer to. Having both the fingering and the notation will mean that the above-mentioned problems will not happen.

The études in this chapter have been a success from both a composer perspective and a performer perspective. Every étude contains multiphonics that are accurate and perform as indicated by the charts. Minor issues have easily been resolved by collaborating with the composers directly, and each piece uses multiphonics in unique ways.

### **The composition of other substantial new works**

The use of multiphonics in bass clarinet music has increased in popularity throughout the duration of this research; composers have requested that they would like to write more substantial works for bass clarinet and also for other combinations of instrumentation. In addition to the études, I have contributed to the growing selection of works by writing '*Screapada*<sup>89</sup>', a substantial solo work, and also a solo variation on the well-known

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<sup>89</sup> Sarah Watts. *Screapadal*, unpublished. 2012

traditional tune *The Carnival of Venice*<sup>90</sup> for use within a theme and variations. Other works with piano, multi-tracked bass clarinets and electroacoustics have also been composed.

**Sarah Watts – *Screapadal*** (CD2, Track 8)

As works started to be composed using the new multiphonic charts and I started to learn the new works and work with composers, I was generally surprised at the varied ways that multiphonics were being used and how effectively they can be used within bass clarinet music. I could see other compositional avenues for using bass clarinet multiphonics that have not been fully explored before. Whilst performing *Minnesang*<sup>91</sup>, Piers Hellawell, one participant noted that in the tutor's recital on the Isle of Raasay bass clarinet course in 2010 the multiphonics were used in a way that was beautiful and effective because they appeared to fit the music and were not just being used as an effect. These multiphonics were Type Ones and were used in a very harmonic and tonal way. They made me think about different ways of using multiphonics within bass clarinet writing.

The use of multiphonics as a harmonic and melodic function in a piece of music that could be accessible to audiences who don't always listen to or appreciate contemporary music has not been fully explored, and the concept of *Screapadal* for solo bass clarinet is the result of my own exploration to see if I could achieve this with my own work.

*Screapadal* is a deserted village on the Hebridean Island of Raasay and is also the title of a poem about the same village by the Scottish poet Sorley MacLean. A non-narrated version has also been created, which will be published at a later date, in which the different verses fuse together to create one single 13 minute-long composition. To stay sympathetic to the genre of the poem and the remote rural island setting, the music is of a

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<sup>90</sup> Sarah Watts. *Variation on the Theme of the Carnival of Venice*, unpublished. 2012.

<sup>91</sup> Piers Hellawell. *Minnesang*, London: Peters Edition. 2010

folk-inspired nature and is intended to be accessible musically to an audience that haven't necessarily heard multiphonics before.

All types of multiphonics are used within *Screapadal*, including subtle spectral sweeps, Type One multiphonics with both exact and approximate pitches and Type Two multiphonics.

The opening of the work (Fig 6.25) is very sparse and free and uses spectral multiphonic glissandi. The approach towards the use of multiphonics within the opening section of the work was to introduce them in as subtle a way as possible. Standard Type One multiphonics would have been too loud and Type Two multiphonics would not have worked as I wanted them to with the fundamental notes in bar three. I chose to explore working with the spectra of Type One harmonics, which, in bars 4 and 7, produced the ethereal and subtle effect needed. A spectral harmonic can be created on any standard fingering, and the concept of production is exactly the same as for Type Ones. With these spectral harmonics, however, the performer aims to play the standard low notes very quietly in dynamic, and by using very delicate changes in embouchure, high frequencies in the harmonic series will appear at a very low volume, and whilst adjusting the embouchure at the same time a player can glissandi through the harmonic spectrum:

**Figure 6.25: Opening of *Screapadal*, by Sarah Watts**

**Slow and Free**

Bass Clarinet in B $\flat$

Repeat - filter in and out with spectral harmonic glissando at ppp

The next miniature section (Fig 6.26) of the piece is only five bars long. The intention of this short movement is that it is evocative of the poem and the words of the poet. This short chordal passage introduces the listener and reader to *Screapadal*, and the poet describes the township as a place so beautiful that no words, picture, poem or music can be used to describe it. The multiphonics chosen were selected for their aesthetic qualities. I chose four different multiphonics that were simple and beautiful, responded well on my instrument and, for me, when put together in this passage, worked to create something that sounds harmonic despite the inharmonic nature of the multiphonics.

**Figure 6.26: Bars 11-15 from *Screapadal*, by Sarah Watts**

The image shows a musical score for B. Cl. in 5/4 time, labeled 'simple and sparse' and 'mp'. It consists of five bars of music. The notation includes a treble clef, a key signature of one sharp (F#), and a 5/4 time signature. The music is written in a single staff. Below the staff, there are five multiphonic fingerings, each represented by a vertical line with circles indicating finger positions. The fingerings are: 1. mp, 2. mp, 3. mp, 4. mp, 5. mp. The multiphonics are: 1. F#4, G4, A4, B4, C5; 2. F#4, G4, A4, B4, C5; 3. F#4, G4, A4, B4, C5; 4. F#4, G4, A4, B4, C5; 5. F#4, G4, A4, B4, C5.

The fifth section (Fig 6.27) of the piece also directly relates to the text, which talks about Rainy. Rainy was the infamous previous owner of Raasay, who cleared many small townships on the island, including Screapadal, sending the island's people to the north of the island where it was harder to work the land and to survive on it. But the poet describes how, despite Rainy's actions, Screapadal remained beautiful and there was nothing that Rainy could do about this. The music for this is represented and inspired by choral writing. Whilst the inharmonic nature of multiphonics means that a chorale cannot be written in the way that Bach would have written one, the soundworld and the chordal nature of this movement, which consists solely of multiphonics, very much has a choral nature to it. The writing is very simple and care was taken to choose beautiful multiphonics that speak

easily to create this effect. I wanted the listener to have some sort of melodic and harmonic structure to cling to, and so the multiphonics chosen all relate to and focus on a note that is centred around the note D. The D is not always the fundamental note and sometimes sounds slightly sharp or flat, but it is a common note in each multiphonic of the movement. By choosing a Type Two multiphonic with two variants at the start and end of the movement, and using the second variant at the end of the second half and the end of the final Da Capo, the piece does in fact loosely appear to be based around D major. It should be stressed that this harmonic interpretation is very much of sorts due to the inception of mistuned notes within each chord. It is also important to remember that the harmonics within a multiphonic will not sound like (for example) a piano chord. The frequencies all sound at different dynamic levels, creating the haunting quality that this movement needs.

**Figure 6.27: Bars 47 - 58 of *Screapadal*, by Sarah Watts**

**Hauntingly - like a choral**

The image displays three systems of musical notation for B. Cl. (Bass Clarinet) from bars 47 to 58. Each system includes a staff with notes and rests, dynamic markings, and fingerings. Below each staff are diagrams of the instrument's keys with black dots representing fingerings and white circles representing breath keys. The first system (bars 47-52) is marked *mp* and ends with 'FINE'. The second system (bars 53-56) is marked *mf*. The third system (bars 57-58) is marked *f* and ends with 'DC al FINE'.

Movement six (Fig 6.28) is based on the section in the poem about the submarines that sail through the Inner Sound, passing Screapadal, and the potential for such a machine to destroy the township and its beauty ('as it was left without people'). To represent this, I wanted to create a sense of menace and suspense, and I chose a mixture of multiphonic tremolos and melodies based on Type One multiphonics. I chose a note centre of B for this, because the choice of multiphonics I could use and the two possible octaves I could use as the fundamental note created the required colour and mood. The harmonic structure is centred loosely (loose due to the nature of multiphonics) around B minor. The tremolos are very subtle and the intervals are very close together. In the multiphonics, either the fundamental or the highest audible frequency stay the same. The centre fundamentals are lower in dynamic, which creates a unique effect on the bass clarinet. For the Type One passages in this movement, the performer chooses the upper partials to play in the second line of the music; however, to bring the movement to a harmonic close, the last line requires the performer to pitch and play the high frequencies. For both passages that feature Type One multiphonics, the standard low note fingering is used as the basis for the multiphonic.

Figure 6.28: Bars 59 - 82 of *Screapadal*, by Sarah Watts

Menacing and full of suspense

6

59 *mf*

B. Cl.

65 *mp*

B. Cl.

71 *mf*

B. Cl.

77 *mp*

B. Cl.

The eighth movement (Fig 6.29) looks at past times in Screapadal before Rainy cleared it and other townships. The multiphonics in the movement reflect the past, the history and the distant past when the township was populated. The melody, which represents a Scottish jig, appears out of the multiphonics and disappears back into them. This is achieved by choosing a note from either the top or the middle of the multiphonic and using this as either a note that travels into the melody or a note that becomes a part of or an end to the melody.



Figure 6.29: Bars 88 - 107 of *Screapadal*, by Sarah Watts

Andante - 6/8 sections are like a jig but not too fast

The musical score for B. Cl. consists of five systems, each representing a different bar in the piece. Each system includes a treble clef staff with notes, rests, and articulation marks, and a corresponding fingering diagram below it. The fingering diagrams use solid black dots for fingers and open circles for the thumb. The systems are labeled with their respective bar numbers: 88, 91, 95, 99, and 103. The key signature changes from one sharp (F#) to one flat (Bb) between bars 91 and 95. The time signature changes from 6/8 to 4/4 between bars 95 and 99, and then to 3/4 between bars 99 and 103. The score concludes with a double bar line at the end of bar 103.

Before the opening movement (Fig 6.25) is reintroduced at the end, the ninth movement (Fig 6.30) signifies the return of the poet talking again about the submarines and their potential to destroy great landmarks. He states that they could even destroy the beauty of Screapadal but that it continues to be beautiful even after Rainy clears the township. I have reused a selection of the multiphonics used in other movements of the piece to represent twelve chiming bells. The use of an image of bells fits the words and means that the audience can clearly hear each multiphonic in the rawest form before the piece draws to a close with a repeat of the opening section.

**Figure 6.30: Bars 108 - 119 of *Screapadal*, by Sarah Watts**

**Tolling and bell-like**

B. Cl. 108 *fp* *sim*

B. Cl. 114

**Sarah Watts – *The Carnival of Venice* variation**

*Cuillin Sound* is a woodwind trio ensemble for flute, clarinet and bassoon. The repertoire that the ensemble performs is mainly classical and the audience on the whole is usually a mainstream music-club audience with traditional tastes. The set of variations on the well-known tune *The Carnival of Venice* was written by the trio, and the majority of the

variations are jovial in character and aim to show off various virtuosic qualities of the instruments in the trio. Instead of using the clarinet, it was decided that the bass clarinet should feature in this arrangement and that each member of the trio would write two variations each.

The first variation for bass clarinet is an unaccompanied solo. It was composed in June 2012, shortly after the first complete draft of charts had been completed, and uses both Type One and Type Two multiphonics. The complete variation can be seen in Fig. 6.31 below.

**Figure 6.31: *The Carnival of Venice variation*<sup>92</sup>, by Sarah Watts**

<sup>92</sup> Sarah Watts. *The Carnival of Venice variation*, unpublished. 2012

Knowing that the target audience for the composition was going to be an audience that was not familiar with the bass clarinet, especially the contemporary bass clarinet, and was not used to contemporary music, the variation had to be carefully constructed. One of the aims of the variation was to make sure that the tune was always audible and obvious within the multiphonics. The opening of the variation (Fig 6.32) uses six multiphonics in a statement in the question and answer phrase of the theme. As seen in chapter four that analyses Type Two multiphonics, the fundamental is not always the most prominent frequency, but it is often used as a harmonic basis for the music composed in the études and other pieces written for this research. For this variation, I decided to find multiphonics that were stable, could be produced at a strong volume and, and most importantly where the melody was represented by the highest most audible frequency of each multiphonic.

**Figure 6.32: The opening half of the phrase of *The Carnival of Venice* variation**



When the multiphonics in Fig. 6.32 are used again in the piece, the numbers are used to indicate the fingering required as seen in Fig. 6.33.

**Figure 6.33: Further usage of multiphonics 1 - 6 in *The Carnival of Venice* variation**



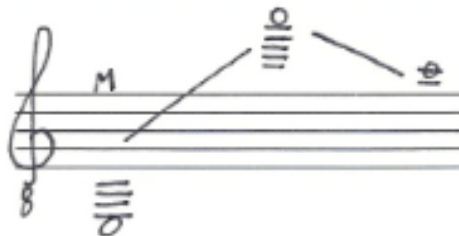
Where Type One multiphonics are used, an M indicates this type of multiphonic. The fundamental note of the Type Ones now appears as the melody in the section shown in Fig. 6.34.

**Figure 6.34: Type One multiphonics in *The Carnival of Venice* variation**



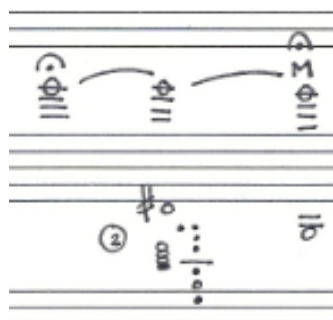
In line three, a multiphonic glissando on a low C is used. This is where I catch the different spectra and frequencies in low C to create a sweeping glissando effect throughout the upper octaves of the instrument. An example of this can be seen in Fig. 6.35:

**Figure 6.35: Spectral glissando on a standard low note C fingering**



At times, the multiphonic emerges from a straight note and travels to a Type Two multiphonic, which morphs into a Type One multiphonic, as seen in Fig. 6.36.

**Figure 6.36: Mixing together Type One and Two multiphonics**



The variation also contains some non multiphonic passages of single-line phrases, and the ending (Fig. 8.37) is an ascending chromatic multiphonic scale, again with the highest most audible frequency being the basis for the harmonic construction. The last note is variant five on a low C Type One multiphonic.

**Figure 6.37: Ending of *The Carnival of Venice* Variation**



The variation is written in free time and in a way that allows each multiphonic to speak so that the audience understands the effect. This variation has now been performed all over the UK and has proved successful at every venue; the audience has accepted the contemporary nature of the variation, often asking questions after the concert about the technique and how it is achieved.

**Lola Perrin – *Her Sisters' Notebook* (CD2, Track 9 – excerpt)**

*Her Sisters' Notebook*<sup>93</sup> was composed in December 2011 and was the first piece of music to incorporate my new multiphonic charts and analysis. The multiphonic aspect of the piece evolved out of a performer–composer collaboration; however, the result of this is that the multiphonic section is largely improvisational. The piece consists of ten short movements of several multitrack bass clarinet parts. The piece is based on numerous ideas which come together using multiphonics in the centre of the piece. The piece is

<sup>93</sup> Lola Perrin. *Her Sisters' Notebook*, unpublished. 2011

based on the work of the Greek composer Kassia (810-865AD), who was the earliest recorded female composer, and a contemporary painting called *The Kiss*, by David Oates<sup>94</sup>.

The multiphonics were selected from a small set of early drafts of samples of the new charts. At this stage, they were very much at a testing phase and so it was a very important milestone in the research to be able to use them in a substantial new work. Perrin chose to select the multiphonics by working directly with me and selecting the multiphonics entirely on the way they sounded when I played them. This aesthetic selection of the multiphonics ensured that they would fully fit in and be incorporated into the soundworld, harmonic nature and timbre of the piece as a whole.

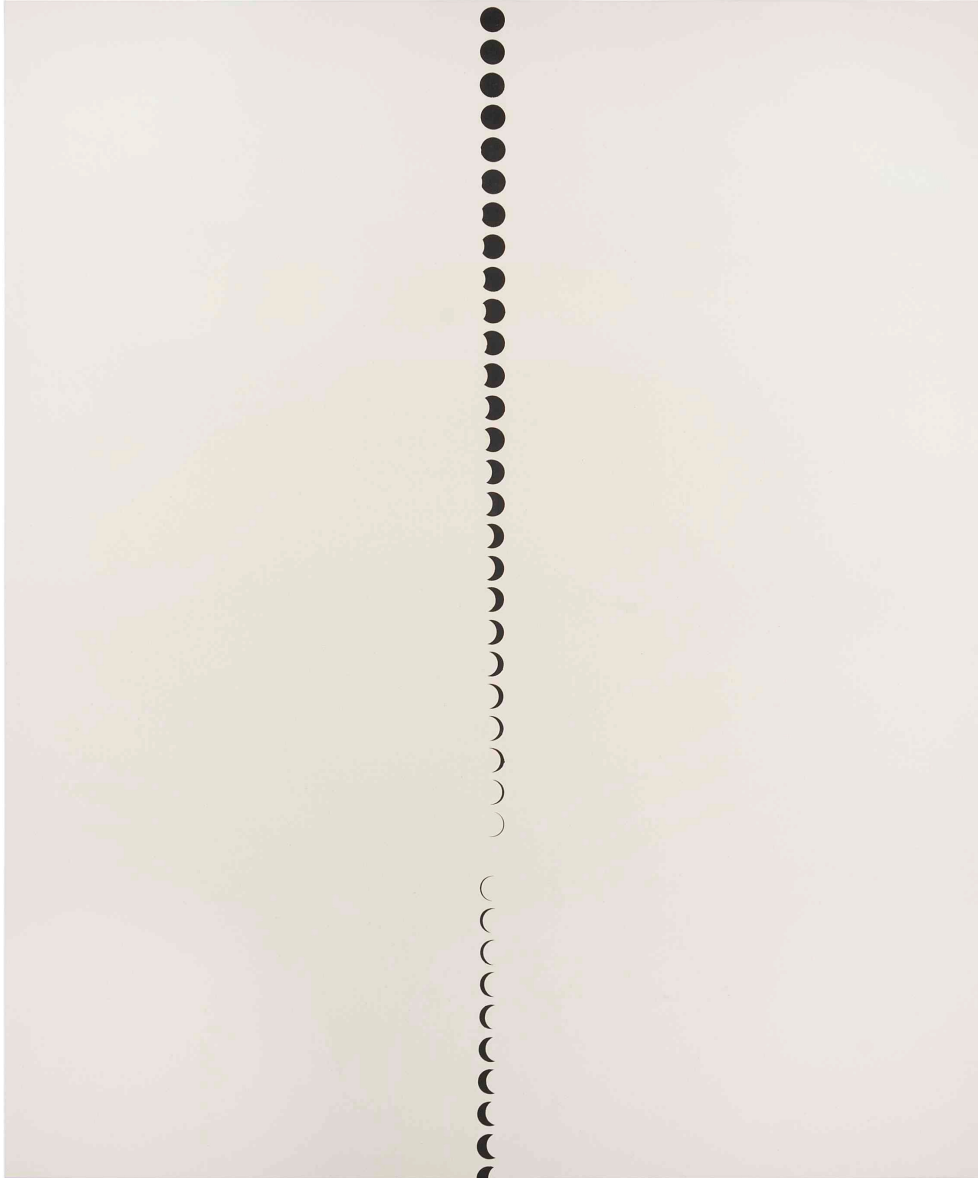
The first movement in which the multiphonics appear is movement five; the multiphonics start to appear above a chorale which is an arrangement of the chosen Kassia melody. Movement six becomes just solo bass clarinet, and the multiphonics effectively become the cadences of the Kassia melody. In movement seven, the music consists solely of multiphonics. The choice of multiphonics is limited to a selected few, but it is the performer's choice as to which of the few to play at each stage of the movements that require them. Movement seven also relates directly to *The Kiss* painting and represents the part of the picture in which the subject appears to fade away before returning again, at which point movement eight sees the disappearance of the multiphonics and the multi-tracked bass clarinets appearing again.

*The Kiss*, by David Oates (Fig. 6.38), is the inspiration for the structure of the ten work pieces. The structure is gained by splitting the picture in to ten parts from the top to the bottom of the painting: The multiphonic section is represented by about the third quarter of the painting, where the black images fade away before subtly returning.

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<sup>94</sup> David Oates. *The Kiss* (painting) <http://www.apststudios.org/artists/DO/index.html>. 2009, 23 August 2013.

**Figure 6.38: *The Kiss*, by David Oates**



**©David Oates**



A section of the music from this section of the piece can be seen in Fig. 6.39 below:

Figure 6.39: Sections 5, 6 and 7 of *Her Sisters' Notebook*, by Lola Perrin

3

40

1 B10A

2

3

4

46

1 B32A/B  
B50A/B

2 *p*

3 *p*

4 *p*

52 S44A/B  
B32A/B  
B49  
B39  
B22  
S27

1 B10A

2

3

4

The multiphonics in the sections shown in Fig. 6.39 are a selection of the multiphonics that were used in the early test charts. These can be seen in Fig. 6.39, where they are written as, for example, B10A, B32A/B and S44A/B, etc. Those selected by Perrin can be seen in Fig. 6.40.

**Figure 6.40: Multiphonics used in *Her Sisters' Notebook*, by Lola Perrin**

The figure illustrates nine multiphonic techniques (M1-M9) used in *Her Sisters' Notebook* by Lola Perrin. Each technique is shown with a fingering diagram and a musical notation example.

- M5:** Fingering: 1 (black), 2 (white), 3 (black), 4 (black), 5 (white). Musical notation: Treble clef, key signature of two sharps (F# and C#), notes G4 and A4.
- M6:** Fingering: 1 (black), 2 (black), 3 (white), 4 (white), 5 (black). Musical notation: Treble clef, key signature of two sharps (F# and C#), notes G4 and A4.
- M7:** Fingering: 1 (white), 2 (black), 3 (black), 4 (white), 5 (white). Musical notation: Treble clef, key signature of two sharps (F# and C#), notes G4 and A4. Includes the text "Or with embouchure change".
- M8:** Fingering: 1 (black), 2 (black), 3 (black), 4 (white), 5 (black). Musical notation: Treble clef, key signature of two sharps (F# and C#), notes G4 and A4.
- M9:** Fingering: 1 (white), 2 (black), 3 (black), 4 (white), 5 (black). Musical notation: Treble clef, key signature of two sharps (F# and C#), notes G4 and A4. Includes the text "Or with embouchure change".
- M1:** Fingering: 1 (white), 2 (black), 3 (black), 4 (black), 5 (white). Musical notation: Treble clef, key signature of two sharps (F# and C#), notes G4 and A4. Includes the text "Or with embouchure change".
- M2:** Fingering: 1 (white), 2 (black), 3 (black), 4 (black), 5 (black). Musical notation: Treble clef, key signature of two sharps (F# and C#), notes G4 and A4. Includes the text "Or with embouchure change".
- M3:** Fingering: 1 (white), 2 (black), 3 (black), 4 (white), 5 (black). Musical notation: Treble clef, key signature of two sharps (F# and C#), notes G4 and A4. Includes the letter "e" below the fingering diagram.
- M4:** Fingering: 1 (white), 2 (black), 3 (black), 4 (white), 5 (black). Musical notation: Treble clef, key signature of two sharps (F# and C#), notes G4 and A4.

The improvised nature of the use of multiphonics makes these three movements very different each time the piece is played. In addition, problems relating to performance can often affect the production of the sound, and so the results of each multiphonic and the effect of movement seven in particular, which is a solo multiphonics only, is unique. I have performed this piece several times, each in very different acoustics setting, from a lecture theatre to a large wood-clad community hall, and in each performance the multiphonics reacted differently. Although I can get each multiphonic to sound as they are notated in my charts, each venue and its characteristics, together with the use of different reeds, result in my having to tackle every choice of multiphonic differently each time I play the piece. Because the composer has allowed a lot of freedom, choice and space in this piece, as a performer I feel very comfortable with being spontaneous and not preselecting what I will do at each venue. The risk of having to choose each multiphonic 'live' on the stage, whilst at the same time playing with the acoustics of each venue to maximise the full bloom and timbre of each multiphonic has resulted in a piece of music that really does make this technique work successfully and produces an exquisite result from both a compositional and performance perspective.

**Patrick Nunn – *Pareidolia 1* (CD2, Track 10 – excerpt)**

*Pareidolia*<sup>95</sup> was composed by Patrick Nunn in January 2012 as a piece for a sensor-enhanced bass clarinet. The concept for the piece arose out of a project in which the composer and performer explored the integration of performance-controlled sensors as way of connecting and shaping digital sound processing, but with the performer having control of the sensors and using them in an expressive way. In *Pareidolia 1*, the sounds and short musical gestures from the bass clarinet become tangled up and morph into the fabric of the electronics. Every performance is unique as the performer has the freedom

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<sup>95</sup> Patrick Nunn. *Pareidolia 1*, unpublished. 2012

and flexibility to manipulate and work with the sensors in a way that enhances each performance differently. Multiphonics are a major focus of this work and give the composer the colour and harmonic content for short sound gestures and the ability for their spectra to travel through various digital software, such as harmonisers.

The multiphonics used were based on selections from the final charts that were being used for student test compositions at the time. The multiphonics selected by the composers were collated according to fundamental pitches and also the intervals that were discovered in the vertical sonority of the multiphonic. Each musical gesture that surrounds a multiphonic is built up from the frequencies in the multiphonics which are specified in my charts. These frequencies are transposed between octaves in the melodic gestures. Whilst quarter tones appear in the multiphonic, in each short melodic phrase these quarter tones are rounded up to the nearest actual pitches.

Figure 6.41 shows an example from page two of the second system of *Pareidolia 1*, and Fig. 6.42 shows the multiphonic analysis used to compose the melodic phrase.

**Figure 6.41: Excerpt one from *Pareidolia 1*, by Patrick Nunn**

The image displays a musical score excerpt. At the top left, there is a vertical stack of notes representing a multiphonic. Below it, a bracket indicates a duration of 'c.8"'. The main staff shows a melodic line starting with a dynamic marking of *p* (piano) and a tempo marking of *c. 72*. The melody consists of several notes, some of which are grouped into triplets, indicated by a '3' over a bracket. The dynamic marking changes to *mf* (mezzo-forte) for the melodic phrase. The score is written on a grand staff with two staves.

Figure 6.42: Analysis of multiphonic used to compose the music in fig. 6.40



Another example from page two (Fig 6.43) shows how the frequencies in the multiphonic when transposed can be used to compose a more energetic gesture. Figure 6.43 shows the analysis used to compose this phrase.

Figure 6.43: Short energetic gesture from *Pareidolia 1*, by Patrick Nunn



Figure 6.44: Analysis of multiphonic used to compose Fig. 8.19



In Fig. 6.43, it should be observed that the composer has used different octaves in the fragment and has decided to omit quarter and eighth tone pitches.

The composer also chose seven multiphonics with fundamental pitches that created a whole-tone scale of sorts, due to the quarter tone or out-of-tune nature of multiphonics.

The harmonic aspects of the multiphonics were observed: some contained a kind of tritone and others major and minor intervals of sorts. Despite this, however, the harmonics were also chosen because of their inharmonic characteristics. This is due to the composer's intentions that the colours in the multiphonics outside of the chromatic system would blend more successfully with the electroacoustic element of the work.

Fig. 6.45 shows how the last two systems bring the seven multiphonics together. The details mentioned in the previous paragraph can also be observed.

**Figure 6.45: Final section of *Pareidolia 1*, by Patrick Nunn**

The figure displays two systems of musical notation for the final section of *Pareidolia 1*. Each system consists of a single staff with a treble clef and a key signature of two sharps (F# and C#). The notation is multiphonic, with notes and accidentals placed on the staff to indicate specific frequencies. Above each system, four brackets indicate the duration of each multiphonic segment: c.6", c.6", c.6", and c.6" for the first system; and c.8", c.8", c.10", and c.12" for the second system. The notes are often grouped with vertical lines and dots, and some segments include checkmarks above them. The second system concludes with a long, thin horizontal line on the staff, possibly representing a sustained or fading sound.

London, January 2012 (rev. June 2012)

**George Nicholson – *Darkness Visible*** (CD2, Track 11 - excerpt)

*Darkness Visible*<sup>96</sup> is a work for bass clarinet and piano and was written for SCAW (Sarah Watts, bass clarinet, and Antony Clare, piano) in June 2012. The recording was released in March 2013 on the CD *Timeless Shades*<sup>97</sup>. As in *Pareidolia 1*, by Patrick Nunn, the Nicholson has mainly used multiphonics from test charts that were compiled for the student test pieces. Several additional multiphonics were added after a performer–composer meeting in which the composer stated that he was looking for specific timbres and harmonies.

The piece is summed up by the poet John Milton’s words in *Paradise Lost*:

“on all sides round

As one great furnace flamed, yet from those flames

No light, but rather darkness visible

Served only to discover sights of woe.”

*Darkness Visible* is a study in darkness and shade that is dominated by the bass registers of both instruments. Movement towards brighter and clearer textures is achieved by the use of bass clarinet multiphonics and harmonics on the piano. Excerpt 1 (Fig. 6.46) shows the use of bass clarinet multiphonics against piano harmonics.

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<sup>96</sup> George Nicholson. *Darkness Visible*, York: UYMP. 2012

<sup>97</sup> SCAW. *Timeless Shades*, CD1, track 2, Cuillin Sound - CUILL1002. 2013

Figure 6.46: Excerpt from *Darkness Visible*, by George Nicholson



It should be noted that the score above is an early draft and that the composer had simply listed multiphonics used in the performance directions, meaning that I could handwrite the fingerings, which can be seen in Fig. 6.47. The score has since been published with all fingerings graphically entered into the score.

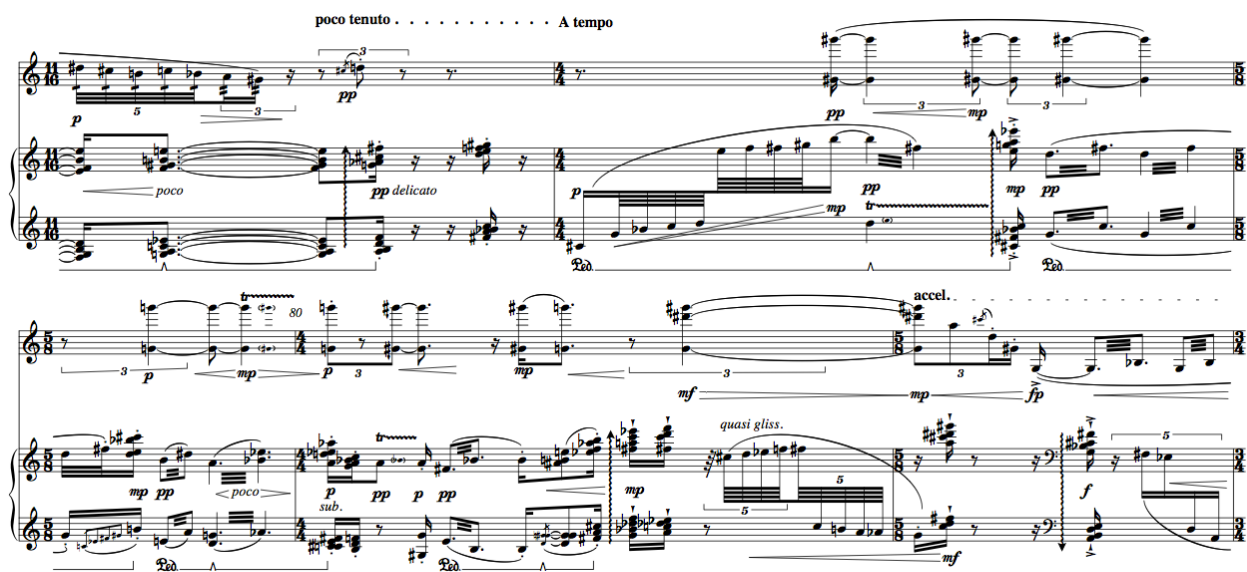
Figure 6.47: Example of handwriting multiphonics in to a score





This worked very well, as it is necessary to perform from the score, and having the graphic fingerings in the score would have altered the spacing of the music and led to having to try to turn many pages during the recording and performance. The composer was inspired by and was interested in multiphonics that sounded close to dyads (a two-note chord). As shown in chapter four on Type Two multiphonics, even a dyad will have other frequencies around it, which is why the term 'close to' is used. Figure 6.48 shows a passage that uses multiphonics that sound as a two-octave unison dyad and the subtle movements between such multiphonics.

**Figure 6.48: Excerpt from *Darkness Visible*, by George Nicholson, which uses octave-dyad multiphonics**



It should be noted that these multiphonics are extremely delicate and quiet in dynamic. The composer has used a sparse accompaniment of mainly very quiet tremolo so that the sound of the multiphonics does not disappear in the textures of the piano. George Nicholson has been so inspired by working with my new multiphonic charts that in November 2012 he completed a set of eight solo pieces called *Soundings*<sup>98</sup>.

<sup>98</sup> George Nicholson. *Soundings*, York: UOYUP. 2013

## Stephen Davismoon – Timeless Shades of Green (CD2, Track 12 – excerpt)

*Timeless Shades of Green*<sup>99</sup> was commissioned by SCAW in April 2012, also for the Timeless Shades CD<sup>100</sup>. The choice of multiphonics is integral to the harmonic nature of the piece, and the chosen multiphonics blend into the piano writing in such a way that the technique of using chords on the bass clarinet seems as natural as using chords on a keyboard. The composer intended the music to be ‘a work expressive of being in anticipation/in contemplation, characterised by a kaleidoscopic use of subtle shifts of sonic energy’. The two examples below show how the composer has achieved his intentions.

In Fig. 6.49, it can be seen that each multiphonic has the top note D sharp as a common feature. It can also be seen that in bars 23, 26 and 28 the fundamental note B (sounding A) of the multiphonic is shared with the pedal bass note A in the piano part. The F sharp fundamental in the multiphonic in bar 24 (sounding E) anticipates the E in the bass of the piano chord in bar 30. The bass clarinet multiphonics throughout this section from bar 23 all have the top note of D sharp (sounding C sharp) in common.

**Figure 6.49: Excerpt from *Timeless Shades of Green*, by Stephen Davismoon**

The image shows a musical score excerpt for Bass Clarinet (B. Cl.) and Piano (Pno.) in 3/4 time. The B. Cl. part features three multiphonic chords labeled as (Type 2/1 2/5), (Type 2/1 1/3), and (Type 2/1 7/5). The piano part includes dynamic markings such as *mp* and *pp*. The score is marked with a '21' at the beginning of each staff, indicating the starting bar number.

<sup>99</sup> Stephen Davismoon. *Timeless Shades of Green*, unpublished. 2012

<sup>100</sup> SCAW. *Timeless Shades*, CD1, track 2, Cuillin Sound - CUILL1002. 2013

Figure 6.49 shows a musical score for Bass Clarinet (B. Cl.) and Piano (Pno.) starting at measure 26. The B. Cl. part features multiphonics labeled as (Type 2/1 1/3), (Type 2/1 13/3), and (Type 2/1 1/3). The Pno. part provides harmonic accompaniment.

The solo bass clarinet passages that use multiphonics are also very harmonic in nature, and care has been taken by the composer to choose multiphonics that have some sort of relationship to each other. Figure 6.49 below shows the use of F sharp (sounding G sharp) as a pedal note and as a central harmonic pitch within the bass clarinet part in this section. When the piano enters at bar 16, the highest note in the right-hand treble clef piano part in the first three chords matches the first three bass clarinet notes in the same bar.

**Figure 6.50: Excerpt two from *Timeless Shades of Green*, by Stephen Davismoon**

Figure 6.50 shows a musical score for Bass Clarinet (B. Cl.) and Piano (Pno.) starting at measure 12. The B. Cl. part features multiphonics labeled as (Type 2/2 16/1) and (Type 2/1 8/3). The Pno. part is silent. Dynamics include *pp* and *mp*. The score is in 6/4 time.

The image shows a musical score for two instruments: B. Cl. (Bass Clarinet) and Pno. (Piano). The score is in 4/4 time and starts at measure 16. The B. Cl. part features a melodic line with a multi-measure rest in measure 17. The Pno. part features a multi-measure rest in measure 17, marked with a piano (*p*) dynamic. The score includes various musical notations such as notes, rests, and dynamic markings.

The majority of the composers mentioned in this chapter have made specific harmonic choices when choosing which multiphonics to feature and have done so in confidence, knowing that what they write will work as they intend. The compositions in this chapter use multiphonics in ways that are harmonic, use the spectra of the multiphonics as part of the musical tonality, feature multiphonics that use specific intervals and use multiphonics that integrate harmonically with other instruments, such as the piano.

This is a positive step and evidence that multiphonics are not only a contemporary technique that can be used as an effect, but can be used harmonically and can be integrated in many different ways within a piece of music. In conclusion, it is clear that the way in which multiphonics are being used within composition has already started to develop by way of the creation of the new correctly analysed and notated charts.

## Chapter 7

### Evaluation of Études and Pieces written using the new SW charts

The new études and pieces in chapter six have all used multiphonics in special and innovative ways. These works show careful and thoughtful use of multiphonics in bass clarinet composition. They also prove that accurately notated charts used as a resource can result in successful, performable and accessible musical compositions.

Composer and performer collaboration has been used for all pieces but to different degrees. *Her Sisters' Notebook*, by Lola Perrin, for example, had a very close collaboration, whereas works such as *Airway*, by Gareth Churchill, and *Darkness Visible*, by George Nicholson, only needed small pockets of advice and offerings from a performer's perspective. The final results do show that, in addition to the effectiveness of the charts, even minimal collaboration and input from a performer can resolve any potential performance issues and render a piece highly successful, and avoids any occasional moments of uncertainty.

One of the most successful aspects of the commissioning and writing of all of the études and pieces is that now it can be proven that multiphonics can be used as an acceptable and workable technique within all areas and genres of composition. Whilst some of the pieces are very contemporary in nature and style, such as *Geometry of Air*, by Iain Matheson, others, such as *Mi Cantare!*, by Miroslav Spasov, and my own *Screapadal* have successfully used multiphonics within a folk-influenced genre. Multiphonics can even be incorporated in a classical setting, e.g. *the Carnival of Venice variation*, and thus can be used to introduce a more mainstream audience to a contemporary technique in an accessible and enjoyable way.

The composition of the new works in chapter six was largely done without composers accessing sound files. For the majority of the études and pieces, I chose not to give the composers general access to audio recordings so that I could see if the new way of presenting audible frequencies within the SW charts gave composers an accurate description of what they expected to hear. It was also important to see how the dynamic guide for each multiphonic was interpreted, knowing that the dynamic advice was based only on my own personal judgement. The majority of composers respected the boundaries that such a guide can offer and were happy with the dynamic possibilities and restraints that the multiphonics offered. Occasionally I was asked if it was possible for the fundamental to be louder in volume, and I had to explain that in general the fundamental is one of the weaker partials in terms of audibility and that a performer will have no control over that aspect of the multiphonic. Without exception, all of the composers were happy with the uneven audibility levels of frequency within each multiphonic and commented that my A, B, C grading system worked well and provided useful and valuable information. One composer who did have advance use of audio samples was George Nicholson, who initially used a selection of charts that were given to students at Sheffield University. These test charts came with the studio-recorded audio samples that had also been used for the spectral analysis. His view is as follows:

‘Initially Sarah provided me with about fifty multiphonic fingerings to consider along with recordings of her playing them. With each fingering she gave me a very clear and detailed description of the harmonic content of the multiphonic, the internal balance of the overtones and the typical dynamic bounds within which they operate best. All this information has proved to be absolutely invaluable<sup>101</sup>.’

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<sup>101</sup> Personal correspondence with George Nicholson, 23 June 2013.

The most important realisation of the composers during the composition of the études and pieces was the fact that to compose successfully using multiphonics, a composer has to gain a very strong understanding of how the bass clarinet works. The level of understanding needed is much higher than that needed when composing without multiphonics. Not only do composers need to understand the technical complexities the performer has to execute to make each multiphonic sound as written, but they must also have a general knowledge of fingering systems and finger patterns for the instrument. As the majority of multiphonics use non-standard fingering, it is not always possible for a player to move between multiphonics quickly. The use of side keys, trill keys and little finger keys that are used to transport a note from a single to a multiple sound can make fast or legato passages impractical. A performer may even have to use unconventional fingering methods to play some multiphonics, such as using the right-hand thumb to play the right-hand trill keys.

Nicholson also understands the basic fingering system for the clarinet and was able to utilise his knowledge to use multiphonics in quite complex ways:

‘Presented with details of the precise harmonic content of each multiphonic as well as the fingering patterns involved, I was able to assemble entire progressions of multiphonic sounds and to envisage transitions and trills, in the certain knowledge that what I was proposing would be absolutely practical in performance terms<sup>102</sup>.’

Educating composers and having to explain how the instrument worked in terms of fingering limitations was at times a difficult aspect of the project. During several performances and workshops, I used *Screapadal* as a demonstration as to how multiphonics can be used in a ‘chordal’ way, and it has been commented upon on several occasions that it is very obvious when listening to this piece that I am writing as a performer who understands my instrument, how it works and also where its limitations lie.

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<sup>102</sup> Personal correspondence with George Nicholson, 23 June 2013.

Some composers found that their expectations with regard to the dynamic variety of multiphonics were greater than the reality. One of the hardest things to accurately advise on in the charts is accurate dynamic information. As discussed in detail in several past chapters, dynamics can cause several problems if the information in the charts is taken literally or ignored.

One might ask, 'What is loud?' and 'What is quiet?' The guide and levels given were what worked for me on one particular day. Whilst I have tried to give as accurate a guide as possible, the dynamics and reactions to different dynamic levels can alter from player to player and in different acoustics and situations. The dynamic guide is an approximate source of information. What must be taken into consideration, however, is the fact that in each multiphonic there are different frequencies that sound at different audible levels. In the majority of cases the fundamental is amongst the quietest of frequencies – several composers mentioned that they expected the lowest note of each multiphonic to be more powerful and audible. This included the composer Iain Matheson: 'In b29 - 32 I imagined the fundamentals would be stronger, but it's a lovely eery sound<sup>103</sup>.'

Another issue was that a single note with a standard fingering will be more powerful in sound and character than a multiphonic. In the majority of cases, the louder multiphonics will not match a single note in terms of actual volume or power. This again raises the question, 'How loud is loud?'

In general, music written using dynamics from the quieter spectrum of dynamic possibilities worked best and pleased the composers. The louder end of the dynamic range, on the whole, was quieter when played than some composers expected. Victor Baez had written some extremely loud dynamics, and even though he clearly understood the limitations of the instrument and the relativeness of the dynamic indications, he has

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<sup>103</sup> Personal correspondence with Iain Matheson, 8 June 2013.



encouraged a performance that moves the performer away from what they are comfortable with, even if this pushes the instrument beyond its limits. Upon hearing my recording of his étude, his advice and thoughts were: ‘Try more extreme dynamics, especially in the f-fff range, and once again disregarding the sonic outcome<sup>104</sup>.’

Before this project was undertaken, multiphonics were very much confined to the realms of contemporary music. They can be a technique that an audience that does not normally listen to or play such music finds hard to understand. The new SW charts have provided a tool so that the multiphonics can be used in such a way that at times they can seem harmonic and fit into a more melodic structure and soundworld. One of the biggest compliments I received about the research has come from musicians and audiences who have accepted multiphonics as a compositional tool that can add special colours and moods to more a traditional writing style. The British bassoonist Laurence Perkins commented on my own work *Screapadal*:

‘In her music (*Screapadal*), Sarah combines some of the modal elements of Scottish traditional folk music with highly evocative use of multiphonics alongside other special techniques such as spectral glissandi and slap tongue – ingredients in what has emerged as a highly evocative and compelling piece, very much along similar lines to the poem that inspired it. For me, this is a model of what 'special techniques' such as multiphonics are all about, and illustrates perfectly the value of such techniques in a meaningful musical context<sup>105</sup>.’

Not only has the range and genres of music that multiphonics can become associated with widened, but composers’ confidence in using them has increased as well. The accuracy of the charts has given composers the freedom to explore the tonalities and characters of

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<sup>104</sup> Personal correspondence with Victor Baez, 3 June 2013.

<sup>105</sup> Personal correspondence with Laurence Perkins, 6 June 2013.

each multiphonic, whilst knowing that they will sound as written. George Nicholson wanted to use a particular sonority and was able to do so by using the SW charts:

‘I became fascinated in particular by a related group of multiphonics that emphasise a double octave of the fundamental pitch... At an early stage in the development of the piece I knew that these double octave sonorities would be central to one of its most characteristic passages, and I asked Sarah to provide fingerings for more multiphonics of the same type. This she was able to do immediately, and to my delight my intuition was borne out by the reality<sup>106</sup>.’

Gareth Churchill wanted multiphonics that were largely devoid of very audible inharmonic frequencies, and was able, ‘with confidence’, to find multiphonics that suited his largely harmonic soundworld:

‘For me personally, therefore, as a composer whose harmonic idiom is, typically, rooted in an aspect of tonal or modal theory the charts permitted me to assimilate, for the first time with confidence, a multiphonic passage into one of my works; knowing, with absolute surety, that I was not upsetting the (harmonic) apple cart<sup>107</sup>.’

The success of the charts has also given the composers the freedom to experiment whilst safe in the knowledge that the notation is secure, in a way that means that they can push the instrument to the extreme whilst using multiphonics. Victor Beaz’s *Multiphonic Study* was one such piece, and consists only of multiphonics except for a couple of interruptive slap-tongue gestures. As a performer, it was easy to fall into the trap of aiming for perfection, meaning that the piece was longer than intended and was played in a way that was safe and accurate. The composer had been fully aware that he would probably push

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<sup>106</sup> Personal correspondence with George Nicholson, 23 June 2013.

<sup>107</sup> Personal correspondence with Gareth Churchill, 7 June 2013.

the instrument beyond what was possible, and after I sent the recording to him, he commented:

‘Another thing that caught my attention immediately was that the recorded piece lasts a little under 6 minutes, whereas I had estimated a total duration of just under 3 minutes. This is an interesting issue, because the "flow" of the piece as it appears in the recording feels somehow very nice and natural, so trying to force it into a much faster tempo might make it sound rushed and sloppy. Nonetheless, it was my hope that speeding up to the tempo I had in mind would rather have a "galvanising" effect, where the piece would have a more "concentrated" kind of energy to it.

Having said this, I am almost certain that the main reason for the difference in estimated and actual durations lies in the nature of the multiphonics, since many of them need a certain time to "speak", of course<sup>108</sup>.’

This conflict in expectations between performer and composer in terms of the composer wanting to, in a way, force the instrument to go out of control is an interesting experiment and in live performance will no doubt provide a unique performance every time.

Composers who have had problems using multiphonics in the past have now written new works and found that the experience and results are totally different to when using other charts. Chapter five looked at the notational and transpositional issue with *Vox* by Marc Yeats. In *quarter-sounds* Yeats has rectified past problems, and he has been very satisfied with the charts for this solo étude:

‘In using these multiphonics in my recent work I have found their spectral analysis to be very accurate; what you see is what you hear, making Sarah's work not only reliable in performance [and notation] but also extremely valuable<sup>109</sup>.’

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<sup>108</sup> Personal correspondence with Victor Baez, 3 June 2013.

<sup>109</sup> Personal correspondence with Marc Yeats, 21 June 2013.

The SW charts have also been an immense help when working in direct collaboration with a composer. Lola Perrin had never worked with contemporary techniques on a woodwind instrument before and her writing is largely tonal, so this was a completely new experience and soundworld for her. Having a large and accurate resource allowed Perrin to choose multiphonics freely and the notation guide allowed her to continue working with them after our session in a way that meant she could hear and understand the complex way in which they are built up:

‘We had a meeting so you could show me a variety of multiphonics. I homed in on these in order to create my composition. You sent me handwritten charts which very precisely indicated the scoring of each multiphonic. I particularly liked this part of the project, it was totally fascinating to me as a composer to consider additional vertical layers of sound (the multiphonics you would contribute live in performance) that would add to my vertically composed work (multi tracking ten pre-composed bass clarinet parts) Once we'd picked the type of multiphonics, I then kept those in front of me at the piano, while I wrote the piece<sup>110</sup>.’

Having multiphonics that sound as notated has had a huge impact on my live performances. It is a known fact that the majority, if not all, performers find performing multiphonics in different acoustics and on different set-ups extremely challenging. With all of the new pieces and études, however, it should be noted that there has been a one hundred per cent success rate in performances and recordings so far. Knowing which notes will sound and therefore being able to accurately pitch the notes before playing them, even in difficult acoustics, has provided the performer with the confidence to trust that the results will be positive. Not only do the multiphonics sound as anticipated, but, because they are accurate, they give the performer a creative licence, in many cases, to

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<sup>110</sup> Personal correspondence with Lola Perrin, 13th June 2013.

play with the acoustic attributes of every performance space. This has been the case with the multiphonic sections in *Screapadal* and *Her Sister's' Notebook*, by Lola Perrin, which have both been performed in large open spaces with generous acoustics and in drier venues such as acoustically dull theatre locations. *Her Sisters' Notebook* was also performed in a large, wooden-clad community hall on the Isle of Raasay, Scotland, with a four-and-a-half second reverb. The multiphonics in the improvised section could be played in a way that was free by blending them into others whilst letting the acoustic naturally take hold of those that were already sounding, which made for a special performance. By way of contrast, *Screapadal* and *quarter-sounds*, by Yeats, were premiered in a low-ceilinged lecture theatre in Ghent, Belgium, with a heavily curtained stage. Yet they still worked even though there was no natural reverb at all in the venue to help enhance create extra atmosphere in the performance. This dry space was perhaps the worst type of space for performing multiphonics – but still they had a one hundred per cent success rate. In short, the results and successes of all of the new works both in terms of compositional success and in terms of recording and live performance have, without question, drawn many positive outcomes, and will prove to be an important stepping stone to encourage more composers and performers to write and play using the new SW charts in the future.

## Chapter 8

### Conclusion

Flexibility is the most important factor for the successful execution of multiphonics from the perspective of both the performer and the composer. The word flexibility has appeared many times within this research, and it is a word that should be and needs to be associated with multiphonics.

The success of the pieces written using the new SW charts in chapter six alone has helped to justify this research and the initial need for a comprehensive study in this field of bass clarinet technique. It should be observed that this research has also highlighted the need for multiphonic use in composition, playing and performance to be further developed, and for both performers and composers to look more closely at this complicated technique. When I have performed and recorded the multiphonics in the études and other new works, the results have been successful and accurate. The execution and production of the multiphonics and therefore the music have worked as notated and are very reliable. This relates to my performance on my bass clarinet using my mouthpiece, my embouchure and my reeds. Despite this, I am confident that the results will also be positive for other players. When performing live and in different acoustic and atmospheric conditions, I feel that the instrument and the physical aspects of performance that are needed to successfully perform each multiphonic change can sometimes affect reliability to a certain degree. I can also confidently state that during the past three years of working closely with multiphonics, I have practised this technique and learnt how to play each multiphonic in my charts and have also learnt how to play multiphonics in different types of compositions and in different pieces. As a result of this work I have learnt that in order to master this incredibly difficult technique I have had to develop and work upon the flexibility of my own

embouchure so that I can attempt to control each multiphonic in every different setting, with each different reed and on different set-ups. In short, through the undertaking of this comprehensive research I now thoroughly know and understand the bass clarinet and the physics behind its sound. To quote Henri Bok:

‘I think the most important elements for me are the knowledge you have performing multiphonics and if you know how to master the technique then you can really do that on many different kinds of instruments, mouthpieces, reeds, etc.<sup>111</sup>.’

This is a quote that has much substance behind it, and I have indeed successfully tested my charts on different set-ups. There are, of course, some multiphonics that will not work on all bass clarinets, and I have tried to omit these from the SW charts. Also, whilst I have tried to ensure that the lowest and highest audible tones in the charts are correct, some performers may achieve slightly different overtones and frequencies to the ones that I have highlighted.

The personal aspect of this project should not be ignored, and it remains a vital consideration when evaluating the short-term, medium-term and long-term success and how this project has further developed the understanding of multiphonics and how they are used. When learning each multiphonic, I concentrated on the most important two notes, which can be seen in column A of my charts (see chapter four). I made the decision to record the complete charts for analysis only once in a studio, with the same technical set-up, reed set-up and instrument set-up for each multiphonic. Due to the nature of multiphonics, had I recorded them again to double-check I would have noticed tiny changes in the audibility of some of the inner partials. A third check would have undoubtedly resulted in further changes. So all the analysis was done using my first recordings, and I spent time learning each before the recording.

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<sup>111</sup> Henri Bok. Telephone interview with Sarah Watts, 10 February 2013.

The audio samples of each multiphonic heard on the CD that accompanies this research were recorded towards the end of the research to a high technical specification with a close microphone position, in a church with a generous acoustic. This was done so that the recording of all of the multiphonics was carried out in a space that will hopefully reflect how a multiphonic will sound and behave in a performance space as opposed to in a small recording studio. Already, using only my ears, I pick up slightly different audibility levels with the inner frequencies. The main partials in column A remain stable, however, and the partials highlighted in the SW charts are still present and stable as notated.

My experience of recording these multiphonics for the CD also justifies my work and my statement that multiphonics need to be practised and learnt. For the analysis recordings, I sometimes had to carry out numerous retakes of the multiphonic to get a stable multiphonic. By the time I came to record the final set, the majority of the multiphonics were recorded in one take and only a limited number of retakes were needed.

It is not only my own ears, but also those of colleagues that have witnessed how working to develop this technique has yielded positive results. For both the recordings of the multiphonics used for analysis and the final recordings of the SW charts and pieces, I used the same recording engineer. Laurence Perkins is also a professional bassoon player so he understands the complicated nature of working with woodwind instruments and the nature of contemporary techniques. After the recording of the final charts and pieces, he commented:

‘I helped produce the initial recordings for Sarah to enable her to do the spectral analysis work, and as a fellow woodwind player I was well aware of the immense technical challenges that producing these multiphonics presented to her – indeed, I had never heard any player attempt this before, or achieve what she did on the instrument. About eighteen months later, I did the final reference recordings of the complete set of multiphonics, which will form the CD that will go with her published work. The difference in that time was quite



dramatic – the later multiphonics were produced with much greater clarity, control, fluency and precision than previously, and this was clearly the result of accurate notation, fingerings and the detailed information that she has spent so much time meticulously preparing<sup>112</sup>.’

The success of incorporating successful multiphonics into compositions depends on the composer’s willingness to allow flexibility in the performance. Without a doubt, the most successful pieces are those that have allowed scope for the multiphonics to flourish and sound naturally and that allow space and time for each multiphonic to do so. This does not mean that the multiphonics can only be used in slow music. Some of the études use multiphonics in faster passages of music, but composer and performer collaboration has resulted in the composer allowing the performer space in the music to prepare and let the multiphonic sound.

Indications and feedback from composers involved in this research have been positive, with all composers finding the results successful and the SW charts easy to use. Some composers have already been encouraged to explore multiphonics further: George Nicholson has since composed *Soundings*<sup>113</sup> in 2012 , which is a further set of solo pieces: ‘The resource is a very rich and exciting one, and, having already composed another large-scale piece for Sarah using multiphonics, I am certain that I will return again and make further explorations of what is available<sup>114</sup>.’

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<sup>112</sup> Personal correspondence with Laurence Perkins, 6 June 2013.

<sup>113</sup> George Nicholson. *Soundings*, York: UYMP, 2013.

<sup>114</sup> Personal correspondence with George Nicholson, 23 June 2013.

Marc Yeats commented that the layout (in terms of the fundamental pitch order) made sorting through, choosing and organising the multiphonics for inclusion in a composition easy and found the final results accurate:

‘Sarah Watt's research and publication around bass clarinet multiphonics has produced a much needed, definitive guide to appropriate and possible multiphonics on the instrument for performers and composers alike. Fingerings are clear and other performative information surrounding the use of the multiphonics such as dynamic range etc..., make useful additions to the work<sup>115</sup>.’

The true level of the overall success of the multiphonic études and pieces written will become more evident over time when other players start to learn and perform them. Early feedback from performers is positive, with Harry Sparnaay remarking:

‘I like the fingering charts and your piece (*Screapadal*). The charts are very helpful for composers<sup>116</sup>.’

My intention is to make all of the material written for this project available for others to use. This includes both the new SW charts and the pieces. Some have already been published and some are being prepared for publishing. The SW charts and a selection of the remaining pieces will be published in a new series by Metropolis publishers, Belgium, in 2014.

Whilst this research has helped to create a resource that I hope will become a standard compositional and performance aid in the future, for me it has only scratched the surface of my work with multiphonics. It has opened further research questions for compositional, performance and teaching areas.

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<sup>115</sup> Personal correspondence with Marc Years, 21 June 2013.

<sup>116</sup> Personal correspondence with Harry Sparnaay, 2 July 2013.

When asking professional players to try to test the SW multiphonic charts, the response has been positive, with players understanding how the charts work and being able to reliably achieve a good success rate using the new SW notation. This aspect of the research has been essential in highlighting and eliminating any multiphonics that don't work across the main makes of instruments and also in highlighting occasional mistakes in my editing. By way of comparison, it is interesting to see how student bass clarinetists need to be taught how to manipulate their embouchure in order to gain the flexibility needed to make multiphonics sound as notated. When I looked at multiphonics with students at Nottingham University, the Royal Northern College of Music and on various music courses, I could see that a high percentage of students cannot instantly play every multiphonic presented to them, often due to their embouchure being too tight and inflexible. What we are taught as students is how to develop and form a perfect embouchure to create the 'perfect' sound. With contemporary techniques, however, a performer has to relearn how to make their embouchure flexible again in order to be able to manipulate the embouchure and therefore the instrument into producing special effects. This applies not only to multiphonics but also to many other contemporary techniques such as glissandi, slap tongue and flutter tongue, and even to the production of quarter and eighth tone pitches. Through the study of a technique such as multiphonic production, a student will learn how subtle changes to embouchure can open up a whole new world of sound, colour, timbre and technical possibilities. The new SW charts and études are a starting point, but it is now necessary to develop more teaching and method resources specifically aimed at students.

A vital area yet to be properly explored is how the use of multiphonics in the teaching of the technique for bass clarinet can help to develop a student's flexibility, tone production and overall control of the instrument. More material and exercises need to be written that can be used to develop a player's skill at successfully playing multiphonics.

These are areas that I intend to continue to research, and they are essential areas that now need to be enhanced so that they can aid the continued development of the bass clarinet in the twenty-first century.

# APPENDIX 1

## Final SW charts, with audio and graphic data

Appendix 1 shows the complete SW Charts in detail.

These charts work together with CD1. CD1 is a data-only CD that contains a file with audio clips of each multiphonic. Each multiphonic is recorded as a straight dynamic and also, where possible, a full dynamic range. It is recommended that to get the best results from these recordings, one should listen to them through headphones or via a set of high-quality speakers. It is recommended that to get the best results from these recordings, one should listen to them through headphones or via a set of high quality speakers.

On CD1, there is a file that contains graphic fingerings for each multiphonic. This files should provide composers with a graphic that can be imported directly into the score via systems such as Sibelius and Finale.

It is recommended that when using the SW multiphonics, the graphics and notations are used together. It should not be assumed that all players will have access to this research and the book that will accompany it. Please credit the multiphonics as the 'SW multiphonics', by Sarah Watts.

Permission is given by the author to use notations and graphics from this thesis and data CD.

# **TYPE TWO MULTIPHONICS WITH ONE VERSION**

**All multiphonics are in the written key of  
B flat**

SW1

OR a/ b/ c/ *pp - ff*

SW2

C# OR a/ b/ c/ *pp - mp*

SW3

OR a/ b/ c/ *mp - ff*

SW4

OR a/ b/ c/ *pp - ff*

SW5

OR a/ b/ c/ *pp - ff*

SW6

OR a/ b/ c/ *pp - ff*

**SW7**

OR

*pp - ff*

**SW8**

OR

*pp - ff*

**SW9**

OR

*pp - f*

**SW10**

OR

*pp - ff*

**SW11**

OR

*p - mf*

**SW12**

OR

*p - mf*



SW13

OR *pp - f*

SW14

OR *pp*

SW15

OR *p - mf*

SW16

OR *pp - ff*

SW17

OR *pp - f*

SW18

OR *p - pp*

**SW19**

OR *pp*

**SW20**

OR *p-ff*

**SW21**

OR *pp-ff*

**SW22**

OR *p-mp*

**SW23**

OR *pp-mp*

**SW24**

OR *pp-mf*

SW25

OR *pp - mp*

SW26

OR *pp - p*

SW27

OR *pp - mp*

SW28

OR *pp - mp*

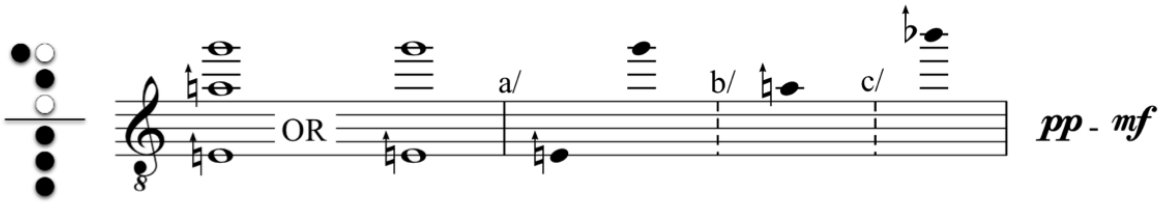
SW29

OR *pp - mf*

SW30

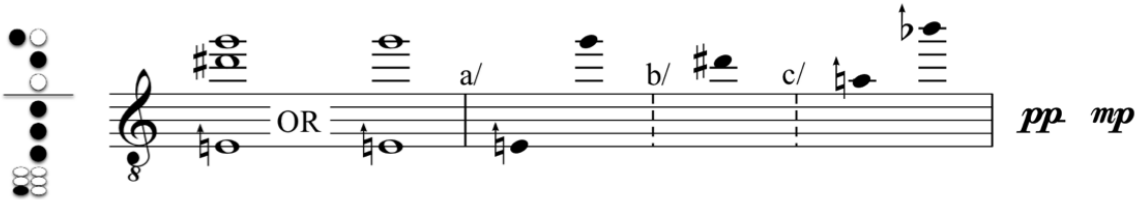
OR *mp*

SW31



Musical notation for SW31. It features a treble clef and a key signature of one flat (B-flat). The notation includes a series of chords and notes, with an 'OR' marking. The notes are labeled 'a/', 'b/', and 'c/'. The dynamic range is indicated as *pp - mf*. Fingerings are shown with black and white dots above and below the notes.

SW32



Musical notation for SW32. It features a treble clef and a key signature of two sharps (D major). The notation includes a series of chords and notes, with an 'OR' marking. The notes are labeled 'a/', 'b/#', and 'c/'. The dynamic range is indicated as *pp mp*. Fingerings are shown with black and white dots above and below the notes.

SW33



Musical notation for SW33. It features a treble clef and a key signature of one flat (B-flat). The notation includes a series of chords and notes, with an 'OR' marking. The notes are labeled 'a/', 'b/b', and 'c/'. The dynamic range is indicated as *pp - mf*. Fingerings are shown with black and white dots above and below the notes.

SW34



Musical notation for SW34. It features a treble clef and a key signature of one sharp (F#). The notation includes a series of chords and notes, with an 'OR' marking. The notes are labeled 'a/', 'b/b', and 'c/'. The dynamic range is indicated as *pp- f*. Fingerings are shown with black and white dots above and below the notes.

SW35



Musical notation for SW35. It features a treble clef and a key signature of two sharps (D major). The notation includes a series of chords and notes, with an 'OR' marking. The notes are labeled 'a/', 'b/#', and 'c/'. The dynamic range is indicated as *pp - mf*. Fingerings are shown with black and white dots above and below the notes.

SW36



Musical notation for SW36. It features a treble clef and a key signature of two sharps (D major). The notation includes a series of chords and notes, with an 'OR' marking. The notes are labeled 'a/', 'b/', and 'c/'. The dynamic range is indicated as *pp - mp*. Fingerings are shown with black and white dots above and below the notes.

**SW37**

*pp - f*

**SW38**

*pp - pp*

**SW39**

*pp - mf*

**SW40**

*pp - f*

**SW41**

*pp - mp*

**SW42**

*pp - mp*

SW43



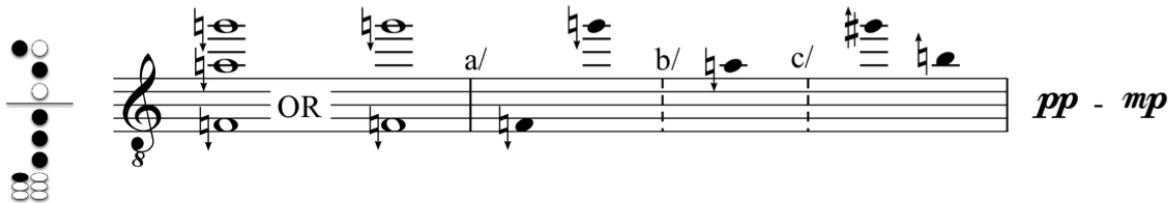
Musical notation for SW43. It features a treble clef and a key signature of one sharp (F#). The notation includes a series of chords and melodic lines. Above the staff, there are diagrams showing fingerings for the right hand (black dots) and left hand (white dots) on the strings. The notation is divided into sections labeled 'a/', 'b/', and 'c/'. The word 'OR' is written between the first and second measures. The dynamic marking is *pp - f*.

SW44



Musical notation for SW44. It features a treble clef and a key signature of one sharp (F#). The notation includes a series of chords and melodic lines. Above the staff, there are diagrams showing fingerings for the right hand (black dots) and left hand (white dots) on the strings. The notation is divided into sections labeled 'a/', 'b/', and 'c/'. The word 'OR' is written between the first and second measures. The dynamic marking is *p - f*.

SW45



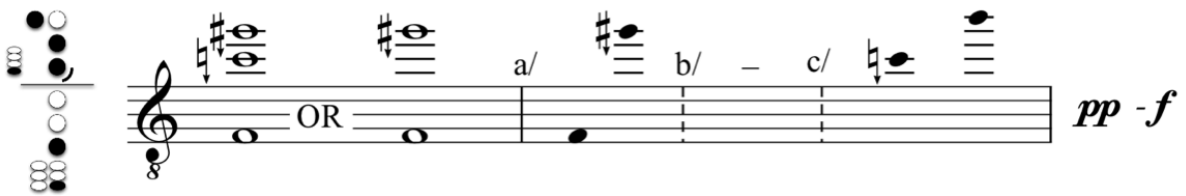
Musical notation for SW45. It features a treble clef and a key signature of one sharp (F#). The notation includes a series of chords and melodic lines. Above the staff, there are diagrams showing fingerings for the right hand (black dots) and left hand (white dots) on the strings. The notation is divided into sections labeled 'a/', 'b/', and 'c/'. The word 'OR' is written between the first and second measures. The dynamic marking is *pp - mp*.

SW46



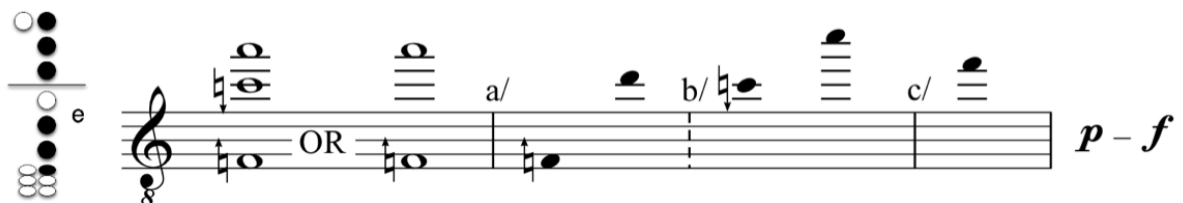
Musical notation for SW46. It features a treble clef and a key signature of one sharp (F#). The notation includes a series of chords and melodic lines. Above the staff, there are diagrams showing fingerings for the right hand (black dots) and left hand (white dots) on the strings. The notation is divided into sections labeled 'a/', 'b/', and 'c/'. The word 'OR' is written between the first and second measures. The dynamic marking is *pp - ff*.

SW47



Musical notation for SW47. It features a treble clef and a key signature of one sharp (F#). The notation includes a series of chords and melodic lines. Above the staff, there are diagrams showing fingerings for the right hand (black dots) and left hand (white dots) on the strings. The notation is divided into sections labeled 'a/', 'b/', and 'c/'. The word 'OR' is written between the first and second measures. The dynamic marking is *pp - f*.

SW48



Musical notation for SW48. It features a treble clef and a key signature of one sharp (F#). The notation includes a series of chords and melodic lines. Above the staff, there are diagrams showing fingerings for the right hand (black dots) and left hand (white dots) on the strings. The notation is divided into sections labeled 'a/', 'b/', and 'c/'. The word 'OR' is written between the first and second measures. The dynamic marking is *p - f*.

SW49

OR a/ b/ c/ *pp - ff*

SW50

OR a/ b/ c/ *pp - ff*

SW51

OR a/ b/ c/ - *pp - f*

SW52

OR a/ b/ c/ *p - mf*

SW53

OR a/ b/ c/ *pp - f*

SW54

OR a/ b/ c/ *pp - ff*

SW55

*p - mp*

SW56

*p*

SW57

*pp - p*

SW58

*pp - mp*

SW59

*pp - mf*

SW60

*pp - mp*



SW61

OR

*pp - mp*

SW62

OR

*pp - p*

SW63

OR

*pp - mp*

SW64

OR

*pp - f*

SW65

OR

*p - mf*

SW66

OR

*p - mf*

SW67

SW68

SW69

SW70

SW71

SW72

SW73

*pp - p*

SW74

*pp - mp*

SW75

*p - ff*

SW76

*pp - f*

SW77

*pp - mf*

SW78

*pp - f*

SW79

Musical notation for SW79. It features a treble clef, an 8va marking, and an 'OR' (Octave Reduction) marking. The notation includes a series of chords and notes: a/ (A), b/# (B), and c/ (C). The dynamic range is indicated as *pp-f*.

SW80

Musical notation for SW80. It features a treble clef, an 8va marking, and an 'OR' (Octave Reduction) marking. The notation includes a series of chords and notes: a/ (A), b/ (B), b (B-flat), and c/ (C). The dynamic range is indicated as *pp-mf*.

SW81

Musical notation for SW81. It features a treble clef, an 8va marking, and an 'OR' (Octave Reduction) marking. The notation includes a series of chords and notes: a/ (A), b/ (B), and c/ (C). The dynamic marking is *p*.

SW82

Musical notation for SW82. It features a treble clef, an 8va marking, and an 'OR' (Octave Reduction) marking. The notation includes a series of chords and notes: a/ (A), b/ (B), and c/ (C). The dynamic marking is *pp*.

SW83

Musical notation for SW83. It features a treble clef, an 8va marking, and an 'OR' (Octave Reduction) marking. The notation includes a series of chords and notes: a/ (A), b/ (B), and c/ (C). The dynamic range is indicated as *pp-mp*.

SW84

Musical notation for SW84. It features a treble clef, an 8va marking, and an 'OR' (Octave Reduction) marking. The notation includes a series of chords and notes: a/ (A), b/ (B), and c/ (C). The dynamic range is indicated as *pp-mf*.

SW85

SW86

SW87

SW88

SW89

SW90

SW91

OR a/ b/ c/ *p - f*

SW92

OR a/ b/ c/ *p - f*

SW93

OR a/ b/ c/ *p - f*

SW94

OR a/ b/ c/ *mp - ff*

SW95

OR a/ b/ c/ *pp - mf*

SW96

OR a/ b/ c/ *pp - mp*

SW97

Musical notation for SW97. It features a treble clef and a key signature of one sharp (F#). The notation includes a series of chords and notes: a whole note chord (F#4, A4, C5), followed by a whole note chord (F#4, A4), and then a sequence of notes: a/ (F#4), b/ (A4), and c/ (C5). The dynamic range is indicated as *p - f*.

SW98

Musical notation for SW98. It features a treble clef and a key signature of one sharp (F#). The notation includes a series of chords and notes: a whole note chord (F#4, A4), followed by a whole note chord (F#4, A4), and then a sequence of notes: a/ (F#4), b/ (A4), and c/ (C5). The dynamic range is indicated as *p - f*.

SW99

Musical notation for SW99. It features a treble clef and a key signature of one sharp (F#). The notation includes a series of chords and notes: a whole note chord (F#4, A4), followed by a whole note chord (F#4, A4), and then a sequence of notes: a/ (F#4), b/ (A4), and c/ (C5). The dynamic range is indicated as *p - f*.

SW100

Musical notation for SW100. It features a treble clef and a key signature of one sharp (F#). The notation includes a series of chords and notes: a whole note chord (F#4, A4), followed by a whole note chord (F#4, A4), and then a sequence of notes: a/ (F#4), b/ (A4), and c/ (C5). The dynamic range is indicated as *ppp*.

SW101

Musical notation for SW101. It features a treble clef and a key signature of one sharp (F#). The notation includes a series of chords and notes: a whole note chord (F#4, A4), followed by a whole note chord (F#4, A4), and then a sequence of notes: a/ (F#4), b/ (A4), and c/ (C5). The dynamic range is indicated as *pp - p*.

SW102

Musical notation for SW102. It features a treble clef and a key signature of one sharp (F#). The notation includes a series of chords and notes: a whole note chord (F#4, A4), followed by a whole note chord (F#4, A4), and then a sequence of notes: a/ (F#4), b/ (A4), and c/ (C5). The dynamic range is indicated as *pp - f*.

SW103

Musical notation for SW103: Treble clef, key signature of two sharps (F# and C#), 8va. Chords: F#m (OR), F#m, a/ (F#m), b/ (F#m), c/ (F#m). Dynamics: *f*.

SW104

Musical notation for SW104: Treble clef, key signature of two sharps (F# and C#), 8va. Chords: F#m (OR), F#m, a/ (F#m), b/ (F#m), c/ (F#m). Dynamics: *pp*.

SW105

Musical notation for SW105: Treble clef, key signature of two sharps (F# and C#), 8va. Chords: F#m (OR), F#m, a/ (F#m), b/ (F#m), c/ (F#m). Dynamics: *pp - mp*.

SW106

Musical notation for SW106: Treble clef, key signature of two sharps (F# and C#), 8va. Chords: F#m (OR), F#m, a/ (F#m), b/ (F#m), c/ (F#m). Dynamics: *pp - p*.

SW107

Musical notation for SW107: Treble clef, key signature of two sharps (F# and C#), 8va. Chords: F#m (OR), F#m, a/ (F#m), b/ (F#m), c/ (F#m). Dynamics: *pp - f*.

SW108

Musical notation for SW108: Treble clef, key signature of two sharps (F# and C#), 8va. Chords: F#m (OR), F#m, a/ (F#m), b/ (F#m), c/ (F#m). Dynamics: *p - mp*.



SW109

OR a/ b/ c/ *pp-p*

SW110

OR a/ b/ c/ *pp-p*

SW111

OR a/ b/ c/ *pp-p*

SW112

OR a/ b/ c/ *pp-mp*

SW113

OR a/ b/ c/ *p-mp*

SW114

OR a/ b/ c/ *pp-f*

SW115

1-finger fingering diagram. Musical notation: Treble clef, whole note chord, OR, whole note chord. Notes: a/ (A4), b/ (B4), c/ (C5). Dynamic: *pp*.

SW116

1-finger fingering diagram. Musical notation: Treble clef, whole note chord, OR, whole note chord. Notes: a/ (A4), b/ (B4), c/ (C5). Dynamic: *pp - p*.

SW117

1-finger fingering diagram. Musical notation: Treble clef, whole note chord, OR, whole note chord. Notes: a/ (A4), b/ (B4), c/ (C5). Dynamic: *pp - mf*.

SW118

1-finger fingering diagram. Musical notation: Treble clef, whole note chord, OR, whole note chord. Notes: a/ (A4), b/ (B4), c/ (C5). Dynamic: *pp - mp*.

SW119

1-finger fingering diagram. Musical notation: Treble clef, whole note chord, OR, whole note chord. Notes: a/ (A4), b/ (B4), c/ (C5). Dynamic: *pp - f*.

SW120

1-finger fingering diagram. Musical notation: Treble clef, whole note chord, OR, whole note chord. Notes: a/ (A4), b/ (B4), c/ (C5). Dynamic: *pp - ff*.

SW121



Musical notation for SW121. It features a treble clef and a key signature of two sharps (F# and C#). The notation includes a guitar chord diagram on the left, a treble clef staff with a whole note chord labeled 'OR', and a sequence of notes labeled 'a/', 'b/', and 'c/' with corresponding guitar chord diagrams above them. The dynamic range is indicated as *pp - ff*.

SW122



Musical notation for SW122. It features a treble clef and a key signature of two sharps (F# and C#). The notation includes a guitar chord diagram on the left, a treble clef staff with a whole note chord labeled 'OR', and a sequence of notes labeled 'a/', 'b/', and 'c/' with corresponding guitar chord diagrams above them. The dynamic range is indicated as *pp - ff*.

SW123



Musical notation for SW123. It features a treble clef and a key signature of two sharps (F# and C#). The notation includes a guitar chord diagram on the left, a treble clef staff with a whole note chord labeled 'OR', and a sequence of notes labeled 'a/', 'b/', and 'c/' with corresponding guitar chord diagrams above them. The dynamic range is indicated as *pp - f*.

SW124



Musical notation for SW124. It features a treble clef and a key signature of two sharps (F# and C#). The notation includes a guitar chord diagram on the left, a treble clef staff with a whole note chord labeled 'OR', and a sequence of notes labeled 'a/', 'b/', and 'c/' with corresponding guitar chord diagrams above them. The dynamic range is indicated as *p*.

SW125



Musical notation for SW125. It features a treble clef and a key signature of two sharps (F# and C#). The notation includes a guitar chord diagram on the left, a treble clef staff with a whole note chord labeled 'OR', and a sequence of notes labeled 'a/', 'b/', and 'c/' with corresponding guitar chord diagrams above them. The dynamic range is indicated as *pp - mf*.

SW126



Musical notation for SW126. It features a treble clef and a key signature of two sharps (F# and C#). The notation includes a guitar chord diagram on the left, a treble clef staff with a whole note chord labeled 'OR', and a sequence of notes labeled 'a/', 'b/', and 'c/' with corresponding guitar chord diagrams above them. The dynamic range is indicated as *pp - p*.

SW127



Musical notation for SW127. It features a treble clef and a bass clef. The treble clef part has a whole note chord with a sharp sign, followed by a whole note chord with a sharp sign and a slash, then a whole note chord with a slash and 'a', a whole note chord with a sharp sign and a slash and 'b', and a whole note chord with a slash and 'c'. The bass clef part has a whole note chord with a sharp sign, followed by a whole note chord with a slash and 'OR', a whole note chord with a slash and 'a', a whole note chord with a slash and 'b', and a whole note chord with a slash and 'c'. The dynamic marking is *pp - mp*.

SW128



Musical notation for SW128. It features a treble clef and a bass clef. The treble clef part has a whole note chord with a sharp sign and a slash, followed by a whole note chord with a sharp sign and a slash, then a whole note chord with a slash and 'a', a whole note chord with a slash and 'b', a whole note chord with a slash and 'c', and a whole note chord with a slash and a sharp sign. The bass clef part has a whole note chord with a sharp sign, followed by a whole note chord with a slash and 'OR', a whole note chord with a slash and 'a', a whole note chord with a slash and 'b', and a whole note chord with a slash and 'c'. The dynamic marking is *pp - p*.

SW129



Musical notation for SW129. It features a treble clef and a bass clef. The treble clef part has a whole note chord with a sharp sign and a slash, followed by a whole note chord with a slash and 'a', a whole note chord with a slash and 'b', and a whole note chord with a slash and 'c'. The bass clef part has a whole note chord with a slash and 'OR', a whole note chord with a slash and 'a', a whole note chord with a slash and 'b', and a whole note chord with a slash and 'c'. The dynamic marking is *pp - p*.

SW130



Musical notation for SW130. It features a treble clef and a bass clef. The treble clef part has a whole note chord with a sharp sign and a slash, followed by a whole note chord with a slash and 'a', a whole note chord with a slash and 'b', and a whole note chord with a slash and 'c' with a flat sign. The bass clef part has a whole note chord with a slash and 'OR', a whole note chord with a slash and 'a', a whole note chord with a slash and 'b', and a whole note chord with a slash and 'c'. The dynamic marking is *pp - ff*.

SW131



Musical notation for SW131. It features a treble clef and a bass clef. The treble clef part has a whole note chord with a sharp sign and a slash, followed by a whole note chord with a sharp sign and a slash, then a whole note chord with a slash and 'a', a whole note chord with a slash and 'b', and a whole note chord with a slash and 'c' with a sharp sign. The bass clef part has a whole note chord with a slash and 'OR', a whole note chord with a slash and 'a', a whole note chord with a slash and 'b', and a whole note chord with a slash and 'c'. The dynamic marking is *pp - mp*.

SW132



Musical notation for SW132. It features a treble clef and a bass clef. The treble clef part has a whole note chord with a sharp sign and a slash, followed by a whole note chord with a slash and 'a', a whole note chord with a slash and 'b', and a whole note chord with a slash and 'c' with a sharp sign. The bass clef part has a whole note chord with a slash and 'OR', a whole note chord with a slash and 'a', a whole note chord with a slash and 'b', and a whole note chord with a slash and 'c'. The dynamic marking is *pp - mf*.

SW133



Musical notation for SW133. It features a treble clef and a key signature of one sharp (F#). The notation includes a series of chords and notes: a whole note chord (F#, C, G), followed by a whole note chord (F#, C, G) with the instruction "OR" below it, then a half note chord (F#, C, G) labeled "a/", a half note chord (F#, C, G) labeled "b/", and a half note chord (F#, C, G) labeled "c/". The dynamic range is indicated as *pp* - *f*.

SW134



Musical notation for SW134. It features a treble clef and a key signature of one sharp (F#). The notation includes a series of chords and notes: a whole note chord (F#, C, G), followed by a whole note chord (F#, C, G) with the instruction "OR" below it, then a half note chord (F#, C, G) labeled "a/", a half note chord (F#, C, G) labeled "b/", and a half note chord (F#, C, G) labeled "c/". The dynamic range is indicated as *pp* - *ff*.

SW135



Musical notation for SW135. It features a treble clef and a key signature of one sharp (F#). The notation includes a series of chords and notes: a whole note chord (F#, C, G), followed by a whole note chord (F#, C, G) with the instruction "OR" below it, then a half note chord (F#, C, G) labeled "a/", a half note chord (F#, C, G) labeled "b/", and a half note chord (F#, C, G) labeled "c/". The dynamic range is indicated as *pp* - *mf*.

SW136



Musical notation for SW136. It features a treble clef and a key signature of one sharp (F#). The notation includes a series of chords and notes: a whole note chord (F#, C, G), followed by a whole note chord (F#, C, G) with the instruction "OR" below it, then a half note chord (F#, C, G) labeled "a/", a half note chord (F#, C, G) labeled "b/", and a half note chord (F#, C, G) labeled "c/". The dynamic range is indicated as *pp* - *mf*.

SW137



Musical notation for SW137. It features a treble clef and a key signature of one sharp (F#). The notation includes a series of chords and notes: a whole note chord (F#, C, G), followed by a whole note chord (F#, C, G) with the instruction "OR" below it, then a half note chord (F#, C, G) labeled "a/", a half note chord (F#, C, G) labeled "b/" with a dash below it, and a half note chord (F#, C, G) labeled "c/". The dynamic range is indicated as *pp* - *mp*.

SW138



Musical notation for SW138. It features a treble clef and a key signature of one sharp (F#). The notation includes a series of chords and notes: a whole note chord (F#, C, G), followed by a whole note chord (F#, C, G) with the instruction "OR" below it, then a half note chord (F#, C, G) labeled "a/", a half note chord (F#, C, G) labeled "b/", and a half note chord (F#, C, G) labeled "c/". The dynamic range is indicated as *p*.

SW139



Musical notation for SW139. It features a treble clef, a key signature of one sharp (F#), and a common time signature. The notation includes a series of chords and notes across four measures. Above the staff, there are diagrams showing fingerings for the right hand (black dots) and left hand (white dots) on the piano keyboard. The notes are: Measure 1: OR (octave reduction) with a whole note chord (F#, C#); Measure 2: a/ with a whole note chord (F#, C#); Measure 3: b/ with a whole note chord (F#, C#); Measure 4: c/ with a whole note chord (F#, C#). The dynamic marking is *p - mp*.

SW140



Musical notation for SW140. It features a treble clef, a key signature of one sharp (F#), and a common time signature. The notation includes a series of chords and notes across four measures. Above the staff, there are diagrams showing fingerings for the right hand (black dots) and left hand (white dots) on the piano keyboard. The notes are: Measure 1: OR (octave reduction) with a whole note chord (F#, C#); Measure 2: a/ with a whole note chord (F#, C#); Measure 3: b/ with a whole note chord (F#, C#); Measure 4: c/ with a whole note chord (F#, C#). The dynamic marking is *pp - p*.

SW141



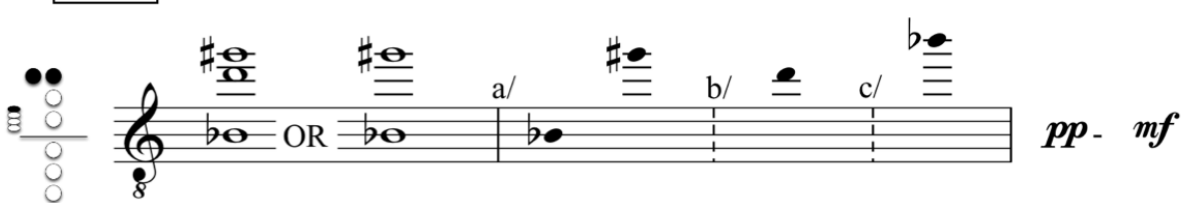
Musical notation for SW141. It features a treble clef, a key signature of one sharp (F#), and a common time signature. The notation includes a series of chords and notes across four measures. Above the staff, there are diagrams showing fingerings for the right hand (black dots) and left hand (white dots) on the piano keyboard. The notes are: Measure 1: OR (octave reduction) with a whole note chord (F#, C#); Measure 2: a/ with a whole note chord (F#, C#); Measure 3: b/ with a whole note chord (F#, C#); Measure 4: c/ with a whole note chord (F#, C#). The dynamic marking is *pp - mf*.

SW142



Musical notation for SW142. It features a treble clef, a key signature of one sharp (F#), and a common time signature. The notation includes a series of chords and notes across four measures. Above the staff, there are diagrams showing fingerings for the right hand (black dots) and left hand (white dots) on the piano keyboard. The notes are: Measure 1: OR (octave reduction) with a whole note chord (F#, C#); Measure 2: a/ with a whole note chord (F#, C#); Measure 3: b/ with a whole note chord (F#, C#); Measure 4: c/ with a whole note chord (F#, C#). The dynamic marking is *pp - f*.

SW143



Musical notation for SW143. It features a treble clef, a key signature of one sharp (F#), and a common time signature. The notation includes a series of chords and notes across four measures. Above the staff, there are diagrams showing fingerings for the right hand (black dots) and left hand (white dots) on the piano keyboard. The notes are: Measure 1: OR (octave reduction) with a whole note chord (F#, C#); Measure 2: a/ with a whole note chord (F#, C#); Measure 3: b/ with a whole note chord (F#, C#); Measure 4: c/ with a whole note chord (F#, C#). The dynamic marking is *pp - mf*.

SW144



Musical notation for SW144. It features a treble clef, a key signature of one sharp (F#), and a common time signature. The notation includes a series of chords and notes across four measures. Above the staff, there are diagrams showing fingerings for the right hand (black dots) and left hand (white dots) on the piano keyboard. The notes are: Measure 1: OR (octave reduction) with a whole note chord (F#, C#); Measure 2: a/ with a whole note chord (F#, C#); Measure 3: b/ with a whole note chord (F#, C#); Measure 4: c/ with a whole note chord (F#, C#). The dynamic marking is *pp - mf*.

SW145

OR

*pp - mp*

SW146

OR

*pp - mp*

SW147

OR

*pp - mf*

SW148

OR

*pp - f*

SW149

OR

*pp - mf*

SW150

OR

*pp - f*

SW151

pp - mp

SW152

pp - f

SW153

pp - mf

SW154

pp - mf

SW155

pp - mf

SW156

pp - f



SW157



Musical notation for SW157. It features a treble clef and a bass clef with an 8. The notation includes a series of chords and notes, with dynamic markings *pp* and *f*. The notes are labeled with 'a/', 'b/', and 'c/'.

SW158



Musical notation for SW158. It features a treble clef and a bass clef with an 8. The notation includes a series of chords and notes, with dynamic markings *pp* and *mf*. The notes are labeled with 'a/', 'b/b', and 'c/'.

SW159



Musical notation for SW159. It features a treble clef and a bass clef with an 8. The notation includes a series of chords and notes, with dynamic markings *pp* and *mp*. The notes are labeled with 'a/', 'b/' and 'c/'.

SW160



Musical notation for SW160. It features a treble clef and a bass clef with an 8. The notation includes a series of chords and notes, with dynamic markings *pp* and *mf*. The notes are labeled with 'a/', 'b/' and 'c/'.

SW161



Musical notation for SW161. It features a treble clef and a bass clef with an 8. The notation includes a series of chords and notes, with dynamic markings *pp* and *p*. The notes are labeled with 'a/', 'b/' and 'c/'.


# **TYPE TWO MULTIPHONICS WITH TWO VERSIONS**

SW162

i/ *pp - mp*



ii/ *pp - ff*



SW163

i/ *pp - mp*



ii/ *pp - f*



SW164

i/ *pp - mp*



ii/ *pp - ff*



SW165




i/ OR *pp - f*

ii/ OR *pp - ff*

Detailed description: This block contains a fingerboard diagram on the left, showing a guitar neck with frets 1-5. The first string has a black dot at fret 1, and the second string has a black dot at fret 1 and a white dot at fret 2. The right side shows two musical staves. Staff i/ is in G major, starting with a G chord (x23332) and moving through notes G, A, B, C. Staff ii/ is in G major, starting with a G chord (x23332) and moving through notes G, A, B, C. Dynamics range from *pp* to *f* or *ff*.

SW166



i/ OR *pp - mp*

ii/ OR *pp - f*

Detailed description: This block contains a fingerboard diagram on the left, showing a guitar neck with frets 1-5. The first string has a black dot at fret 1, and the second string has a black dot at fret 1 and a white dot at fret 2. The right side shows two musical staves. Staff i/ is in G major, starting with a G chord (x23332) and moving through notes G, A, B, C. Staff ii/ is in G major, starting with a G chord (x23332) and moving through notes G, A, B, C. Dynamics range from *pp* to *mp* or *f*.

SW167

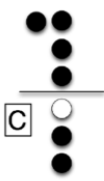


i/ OR *pp - mf*

ii/ OR *pp - f*

Detailed description: This block contains a fingerboard diagram on the left, showing a guitar neck with frets 1-5. The first string has a black dot at fret 1, and the second string has a black dot at fret 1 and a white dot at fret 2. The right side shows two musical staves. Staff i/ is in G major, starting with a G chord (x23332) and moving through notes G, A, B, C. Staff ii/ is in G major, starting with a G chord (x23332) and moving through notes G, A, B, C. Dynamics range from *pp* to *mf* or *f*.

SW168



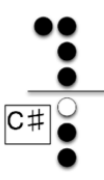
i/ OR *pp - mp*

Musical notation for the first position (i/). It shows a treble clef with a key signature of one sharp (F#). The notes are: F#4, G4, A4, B4, C5. The first measure is marked 'OR' and contains a whole note F#4. The second measure is marked 'a/' and contains a whole note G4. The third measure is marked 'b/' and contains a whole note A4. The fourth measure is marked 'c/' and contains a whole note B4. The dynamic range is *pp - mp*.

ii/ OR *pp - ff*

Musical notation for the second position (ii/). It shows a treble clef with a key signature of one sharp (F#). The notes are: F#4, G4, A4, B4, C5. The first measure is marked 'OR' and contains a whole note F#4. The second measure is marked 'a/' and contains a whole note G4. The third measure is marked 'b/' and contains a whole note A4. The fourth measure is marked 'c/' and contains a whole note B4. The dynamic range is *pp - ff*.

SW169



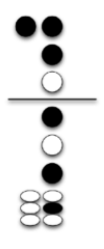
i/ OR *pp - f*

Musical notation for the first position (i/). It shows a treble clef with a key signature of one sharp (F#). The notes are: F#4, G4, A4, B4, C5. The first measure is marked 'OR' and contains a whole note F#4. The second measure is marked 'a/' and contains a whole note G4. The third measure is marked 'b/' and contains a whole note A4. The fourth measure is marked 'c/' and contains a whole note B4. The dynamic range is *pp - f*.

ii/ OR *pp - ff*

Musical notation for the second position (ii/). It shows a treble clef with a key signature of one sharp (F#). The notes are: F#4, G4, A4, B4, C5. The first measure is marked 'OR' and contains a whole note F#4. The second measure is marked 'a/' and contains a whole note G4. The third measure is marked 'b/' and contains a whole note A4. The fourth measure is marked 'c/' and contains a whole note B4. The dynamic range is *pp - ff*.

SW170



i/ OR *pp - ff*

Musical notation for the first position (i/). It shows a treble clef with a key signature of one sharp (F#). The notes are: F#4, G4, A4, B4, C5. The first measure is marked 'OR' and contains a whole note F#4. The second measure is marked 'a/' and contains a whole note G4. The third measure is marked 'b/' and contains a whole note A4. The fourth measure is marked 'c/' and contains a whole note B4. The dynamic range is *pp - ff*.

ii/ OR *pp - ff*

Musical notation for the second position (ii/). It shows a treble clef with a key signature of one sharp (F#). The notes are: F#4, G4, A4, B4, C5. The first measure is marked 'OR' and contains a whole note F#4. The second measure is marked 'a/' and contains a whole note G4. The third measure is marked 'b/' and contains a whole note A4. The fourth measure is marked 'c/' and contains a whole note B4. The dynamic range is *pp - ff*.

SW171



i/ OR *pp - p*

ii/ OR *p - ff*

Detailed description: This block contains two musical staves for exercise SW171. The first staff, labeled 'i/', shows a sequence of chords: a triad with notes G4, B4, and D5 (marked with a sharp sign), followed by a dyad with notes G4 and B4, and then a dyad with notes G4 and A4. The second staff, labeled 'ii/', shows a sequence of chords: a triad with notes G4, B4, and D5 (marked with a sharp sign), followed by a dyad with notes G4 and B4, and then a dyad with notes G4 and A4. The dynamic markings are *pp - p* for the first staff and *p - ff* for the second staff. A hand diagram to the left shows the fingerings for the first staff: index finger on G4, middle finger on B4, and ring finger on D5.

SW172



i/ OR *pp - p*

ii/ OR *pp - ff*

Detailed description: This block contains two musical staves for exercise SW172. The first staff, labeled 'i/', shows a sequence of chords: a triad with notes G4, B4, and D5 (marked with a sharp sign), followed by a dyad with notes G4 and B4, and then a dyad with notes G4 and A4. The second staff, labeled 'ii/', shows a sequence of chords: a triad with notes G4, B4, and D5 (marked with a sharp sign), followed by a dyad with notes G4 and B4, and then a dyad with notes G4 and A4. The dynamic markings are *pp - p* for the first staff and *pp - ff* for the second staff. A hand diagram to the left shows the fingerings for the first staff: index finger on G4, middle finger on B4, and ring finger on D5.

SW173



i/ OR *pp - mp*

ii/ OR *pp - f*

Detailed description: This block contains two musical staves for exercise SW173. The first staff, labeled 'i/', shows a sequence of chords: a triad with notes G4, B4, and D5 (marked with a sharp sign), followed by a dyad with notes G4 and B4, and then a dyad with notes G4 and A4. The second staff, labeled 'ii/', shows a sequence of chords: a triad with notes G4, B4, and D5 (marked with a sharp sign), followed by a dyad with notes G4 and B4, and then a dyad with notes G4 and A4. The dynamic markings are *pp - mp* for the first staff and *pp - f* for the second staff. A hand diagram to the left shows the fingerings for the first staff: index finger on G4, middle finger on B4, and ring finger on D5.

SW174

i/ *pp - mf*

The musical staff for SW174 i/ shows a sequence of chords: a triad of G#4, B4, and D5; a dyad of G#4 and B4; a dyad of A4 and B4; a dyad of B4 and C#5; and a dyad of C#5 and D5. The notes are marked with 'a/' above the first two chords and 'b/' above the last two. The dynamic range is *pp - mf*.



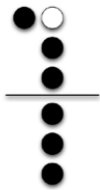
ii/ *pp - ff*

The musical staff for SW174 ii/ shows a sequence of chords: a triad of G#4, B4, and D5; a dyad of G#4 and B4; a dyad of A4 and B4; a dyad of B4 and C#5; and a dyad of C#5 and D5. The notes are marked with 'a/' above the first two chords and 'b/' above the last two. The dynamic range is *pp - ff*.

SW175

i/ *pp - p*

The musical staff for SW175 i/ shows a sequence of chords: a triad of G#4, B4, and D5; a dyad of G#4 and B4; a dyad of A4 and B4; a dyad of B4 and C#5; and a dyad of C#5 and D5. The notes are marked with 'a/' above the first two chords and 'b/' above the last two. The dynamic range is *pp - p*.



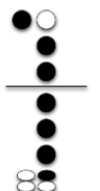
ii/ *pp - mp*

The musical staff for SW175 ii/ shows a sequence of chords: a triad of G#4, B4, and D5; a dyad of G#4 and B4; a dyad of A4 and B4; a dyad of B4 and C#5; and a dyad of C#5 and D5. The notes are marked with 'a/' above the first two chords and 'b/' above the last two. The dynamic range is *pp - mp*.

SW176

i/ *pp - p*

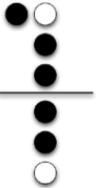
The musical staff for SW176 i/ shows a sequence of chords: a triad of G#4, B4, and D5; a dyad of G#4 and B4; a dyad of A4 and B4; a dyad of B4 and C#5; and a dyad of C#5 and D5. The notes are marked with 'a/' above the first two chords and 'b/' above the last two. The dynamic range is *pp - p*.



ii/ *p - mp*

The musical staff for SW176 ii/ shows a sequence of chords: a triad of G#4, B4, and D5; a dyad of G#4 and B4; a dyad of A4 and B4; a dyad of B4 and C#5; and a dyad of C#5 and D5. The notes are marked with 'a/' above the first two chords and 'b/' above the last two. The dynamic range is *p - mp*.

SW177



i/ OR *pp - mp*

ii/ OR *pp - p*

Detailed description: This block contains two musical exercises for SW177. Exercise i/ shows two staves. The top staff has a treble clef, a key signature of one sharp (F#), and a common time signature. It contains a sequence of chords: a triad (F#, A, C), a dyad (F#, A), a dyad (A, C), a dyad (F#, C), and a whole note (F#). The bottom staff has a bass clef and contains a sequence of chords: a triad (F#, A, C), a dyad (F#, A), a dyad (A, C), a dyad (F#, C), and a whole note (F#). Exercise ii/ shows two staves. The top staff has a treble clef, a key signature of two sharps (F#, C#), and a common time signature. It contains a sequence of chords: a triad (F#, A, C), a dyad (F#, A), a dyad (A, C), a dyad (F#, C), and a whole note (F#). The bottom staff has a bass clef and contains a sequence of chords: a triad (F#, A, C), a dyad (F#, A), a dyad (A, C), a dyad (F#, C), and a whole note (F#).

SW178




i/ OR *pp - mf*

ii/ OR *pp - mf*

Detailed description: This block contains two musical exercises for SW178. Exercise i/ shows two staves. The top staff has a treble clef, a key signature of one sharp (F#), and a common time signature. It contains a sequence of chords: a triad (F#, A, C), a dyad (F#, A), a dyad (A, C), a dyad (F#, C), and a whole note (F#). The bottom staff has a bass clef and contains a sequence of chords: a triad (F#, A, C), a dyad (F#, A), a dyad (A, C), a dyad (F#, C), and a whole note (F#). Exercise ii/ shows two staves. The top staff has a treble clef, a key signature of two sharps (F#, C#), and a common time signature. It contains a sequence of chords: a triad (F#, A, C), a dyad (F#, A), a dyad (A, C), a dyad (F#, C), and a whole note (F#). The bottom staff has a bass clef and contains a sequence of chords: a triad (F#, A, C), a dyad (F#, A), a dyad (A, C), a dyad (F#, C), and a whole note (F#).

SW179



i/ OR *pp - f*

ii/ OR *pp - mf*

Detailed description: This block contains two musical exercises for SW179. Exercise i/ shows two staves. The top staff has a treble clef, a key signature of one sharp (F#), and a common time signature. It contains a sequence of chords: a triad (F#, A, C), a dyad (F#, A), a dyad (A, C), a dyad (F#, C), and a whole note (F#). The bottom staff has a bass clef and contains a sequence of chords: a triad (F#, A, C), a dyad (F#, A), a dyad (A, C), a dyad (F#, C), and a whole note (F#). Exercise ii/ shows two staves. The top staff has a treble clef, a key signature of two sharps (F#, C#), and a common time signature. It contains a sequence of chords: a triad (F#, A, C), a dyad (F#, A), a dyad (A, C), a dyad (F#, C), and a whole note (F#). The bottom staff has a bass clef and contains a sequence of chords: a triad (F#, A, C), a dyad (F#, A), a dyad (A, C), a dyad (F#, C), and a whole note (F#).



SW180

Exercise SW180 consists of two parts, i/ and ii/. Part i/ is written on a treble clef staff with a key signature of one sharp (F#) and a common time signature. It begins with a whole note chord of F#4 and C5, followed by a whole note chord of F#4 and G4. The exercise then proceeds through three measures: a/ (F#4), b/ (F#4 and G4), and c/ (F#4). Part ii/ follows a similar structure but with different voicings and includes a final measure with a whole note chord of F#4 and G4. A dynamic range of *p - mf* is indicated. To the left of the staves is a vertical diagram of a piano keyboard with black and white circles representing the notes used in the exercise.

SW181

Exercise SW181 consists of two parts, i/ and ii/. Part i/ is written on a treble clef staff with a key signature of one sharp (F#) and a common time signature. It begins with a whole note chord of F#4 and C5, followed by a whole note chord of F#4 and G4. The exercise then proceeds through three measures: a/ (F#4), b/ (F#4 and G4), and c/ (F#4). Part ii/ follows a similar structure but with different voicings and includes a final measure with a whole note chord of F#4 and G4. A dynamic range of *pp - mf* is indicated. To the left of the staves is a vertical diagram of a piano keyboard with black and white circles representing the notes used in the exercise.

SW182

Exercise SW182 consists of two parts, i/ and ii/. Part i/ is written on a treble clef staff with a key signature of one sharp (F#) and a common time signature. It begins with a whole note chord of F#4 and C5, followed by a whole note chord of F#4 and G4. The exercise then proceeds through three measures: a/ (F#4), b/ (F#4 and G4), and c/ (F#4). Part ii/ follows a similar structure but with different voicings and includes a final measure with a whole note chord of F#4 and G4. A dynamic range of *pp - mf* is indicated. To the left of the staves is a vertical diagram of a piano keyboard with black and white circles representing the notes used in the exercise.

SW183

Musical notation for SW183. The first staff (i/) shows a treble clef with a key signature of two sharps (F# and C#). The notes are: F#4, C#5, G#4, F#4, C#5, G#4, F#4, C#5. The second staff (ii/) shows a treble clef with a key signature of one sharp (F#). The notes are: F#4, C#5, G#4, F#4, C#5, G#4, F#4, C#5. Both staves include a diagram of the fretboard with fingerings indicated by black and white dots. The dynamic range is *pp - mp*.

SW184

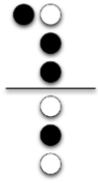
Musical notation for SW184. The first staff (i/) shows a treble clef with a key signature of two sharps (F# and C#). The notes are: F#4, C#5, G#4, F#4, C#5, G#4, F#4, C#5. The second staff (ii/) shows a treble clef with a key signature of one sharp (F#). The notes are: F#4, C#5, G#4, F#4, C#5, G#4, F#4, C#5. Both staves include a diagram of the fretboard with fingerings indicated by black and white dots. The dynamic range is *pp - mf*.

SW185

Musical notation for SW185. The first staff (i/) shows a treble clef with a key signature of two sharps (F# and C#). The notes are: F#4, C#5, G#4, F#4, C#5, G#4, F#4, C#5. The second staff (ii/) shows a treble clef with a key signature of one sharp (F#). The notes are: F#4, C#5, G#4, F#4, C#5, G#4, F#4, C#5. Both staves include a diagram of the fretboard with fingerings indicated by black and white dots. The dynamic range is *pp - mp*.

SW186

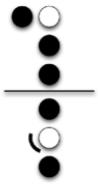
i/ *p - mp*



ii/ *p - mp*

SW187

i/ *p - mp*



ii/ *p - mp*

SW188

i/ *pp - mf*



ii/ *pp - mp*

SW189

i/ *pp - mf*

ii/ *pp - mf*

SW190

i/ *pp - p*

ii/ *pp - p*

SW191

i/ *pp - p*

ii/ *pp - mf*

SW192

i/ OR *pp - mp*

ii/ OR *mp*

SW193

i/ OR *pp - mp*

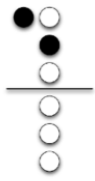
ii/ OR *pp - mp*





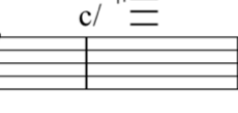
SW194


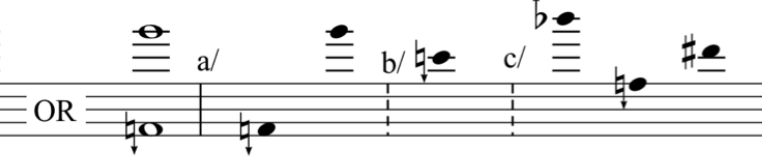



i/ OR *pp - mf*

ii/ OR *pp - ff*

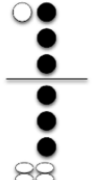
SW195



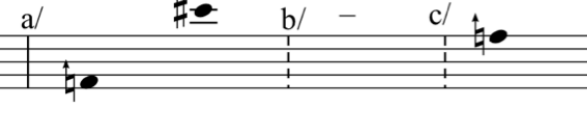
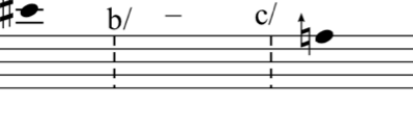






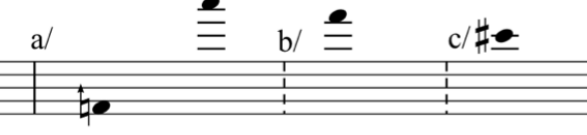

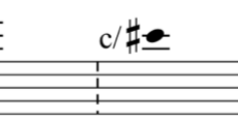
i/  OR  a/  b/  c/  *pp - mp*

ii/  OR  a/  b/  c/  *pp - f*

SW196



i/  OR  a/  b/  -  c/  *pp - p*

ii/  OR  a/  b/  c/  *pp - p*

SW197



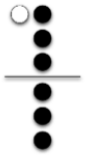
i/  OR  a/  b/  c/  *pp - mf*

ii/  OR  a/  b/  c/  *pp - ff*

SW198

i/ OR *p - mp*

The first staff (i/) shows a sequence of chords: a triad with notes G#4, A4, B4; a dyad with notes A4, B4; a dyad with notes B4, C5; and a dyad with notes C5, B4. The second staff (ii/) shows a sequence of chords: a triad with notes G#4, A4, B4; a dyad with notes A4, B4; a dyad with notes B4, C5; a dyad with notes C5, B4; and a dyad with notes B4, A4.



ii/ OR *p - f*

The second staff (ii/) shows a sequence of chords: a triad with notes G#4, A4, B4; a dyad with notes A4, B4; a dyad with notes B4, C5; a dyad with notes C5, B4; and a dyad with notes B4, A4.

SW199

i/ OR *pp - mp*

The first staff (i/) shows a sequence of chords: a triad with notes G#4, A4, B4; a dyad with notes A4, B4; a dyad with notes B4, C5; and a whole note chord with notes C5, B4.



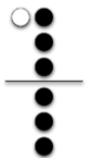
ii/ OR *pp - mf*

The second staff (ii/) shows a sequence of chords: a triad with notes G#4, A4, B4; a dyad with notes A4, B4; a dyad with notes B4, C5; a dyad with notes C5, B4; and a dyad with notes B4, A4.

SW200

i/ OR *pp - mf*

The first staff (i/) shows a sequence of chords: a triad with notes G#4, A4, B4; a dyad with notes A4, B4; a dyad with notes B4, C5; and a dyad with notes C5, B4.



ii/ OR *pp - mp*

The second staff (ii/) shows a sequence of chords: a triad with notes G#4, A4, B4; a dyad with notes A4, B4; a dyad with notes B4, C5; and a dyad with notes C5, B4.

SW201

i/ OR *p - mf*

ii/ OR *p - mf*

SW202

i/ OR *p - mp*

ii/ OR *p - mp*

SW203

i/ OR *pp - mf*

ii/ OR *pp - ff*



SW204

Exercise SW204 consists of two parts, i/ and ii/. Part i/ is written on a treble clef staff with a key signature of two sharps (F# and C#) and a common time signature. It features a sequence of notes: a whole note chord (F#, C#, G), followed by a half note chord (F#, C#), then a half note chord (F#, C#), and finally a half note chord (F#, C#) with a fermata. The notes are labeled 'a/' above the first chord, 'b/' above the second, and 'c/' above the third. The dynamic marking is *pp - p*. Part ii/ is also on a treble clef staff with the same key signature and time signature. It features a sequence of notes: a whole note chord (F#, C#, G), followed by a half note chord (F#, C#), then a half note chord (F#, C#), and finally a half note chord (F#, C#) with a fermata. The notes are labeled 'a/' above the first chord, 'b/' above the second, and 'c/' above the third. The dynamic marking is *pp - ff*. To the left of the staves is a vertical diagram of a piano keyboard with circles representing keys: white circles for white keys and black circles for black keys. The diagram shows the layout of the first few octaves.


SW205



Exercise SW205 consists of two parts, i/ and ii/. Part i/ is written on a treble clef staff with a key signature of two sharps (F# and C#) and a common time signature. It features a sequence of notes: a whole note chord (F#, C#, G), followed by a half note chord (F#, C#), then a half note chord (F#, C#), and finally a half note chord (F#, C#) with a fermata. The notes are labeled 'a/' above the first chord, 'b/' above the second, and 'c/' above the third. The dynamic marking is *pp - ff*. Part ii/ is also on a treble clef staff with the same key signature and time signature. It features a sequence of notes: a whole note chord (F#, C#, G), followed by a half note chord (F#, C#), then a half note chord (F#, C#), and finally a half note chord (F#, C#) with a fermata. The notes are labeled 'a/' above the first chord, 'b/' above the second, and 'c/' above the third. The dynamic marking is *pp - ff*. To the left of the staves is a vertical diagram of a piano keyboard with circles representing keys: white circles for white keys and black circles for black keys. The diagram shows the layout of the first few octaves.

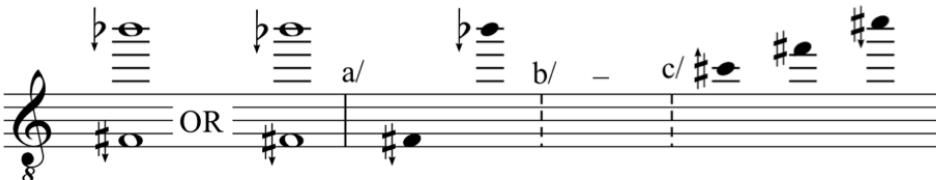
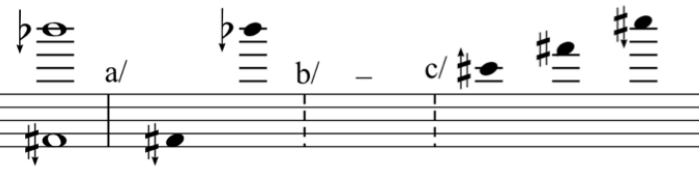
SW206

Exercise SW206 consists of two parts, i/ and ii/. Part i/ is written on a treble clef staff with a key signature of two sharps (F# and C#) and a common time signature. It features a sequence of notes: a whole note chord (F#, C#, G), followed by a half note chord (F#, C#), then a half note chord (F#, C#), and finally a half note chord (F#, C#) with a fermata. The notes are labeled 'a/' above the first chord, 'b/' above the second, and 'c/' above the third. The dynamic marking is *pp - f*. Part ii/ is also on a treble clef staff with the same key signature and time signature. It features a sequence of notes: a whole note chord (F#, C#, G), followed by a half note chord (F#, C#), then a half note chord (F#, C#), and finally a half note chord (F#, C#) with a fermata. The notes are labeled 'a/' above the first chord, 'b/' above the second, and 'c/' above the third. The dynamic marking is *pp - ff*. To the left of the staves is a vertical diagram of a piano keyboard with circles representing keys: white circles for white keys and black circles for black keys. The diagram shows the layout of the first few octaves.

SW207





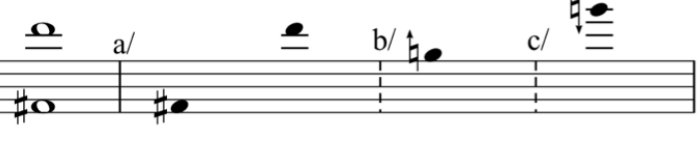
i/  OR  *pp - ff*


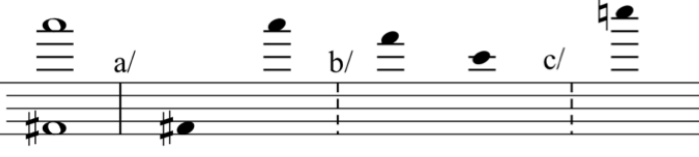
ii/  OR  *pp - ff*

SW207 consists of two exercises, i/ and ii/. Exercise i/ is in G major and consists of two staves. The first staff (i/) has two options: a triad of G4, B4, D5 and a dyad of G4, B4. The second staff (ii/) has two options: a triad of B3, D4, E4 and a dyad of B3, D4. Exercise ii/ is in G major and consists of two staves. The first staff (i/) has two options: a triad of G4, B4, D5 and a dyad of G4, B4. The second staff (ii/) has two options: a triad of B3, D4, E4 and a dyad of B3, D4. The dynamic range is *pp - ff*.

SW208

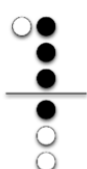



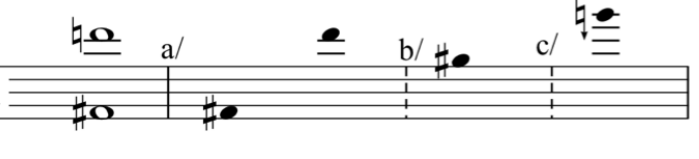
i/  OR  *pp - ff*


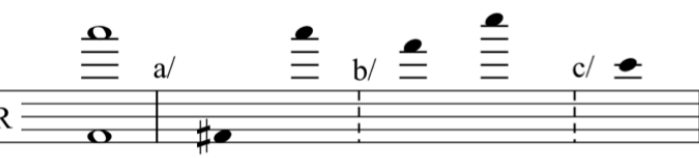
ii/  OR  *pp - mp*

SW208 consists of two exercises, i/ and ii/. Exercise i/ is in G major and consists of two staves. The first staff (i/) has two options: a triad of G4, B4, D5 and a dyad of G4, B4. The second staff (ii/) has two options: a triad of B3, D4, E4 and a dyad of B3, D4. Exercise ii/ is in G major and consists of two staves. The first staff (i/) has two options: a triad of G4, B4, D5 and a dyad of G4, B4. The second staff (ii/) has two options: a triad of B3, D4, E4 and a dyad of B3, D4. The dynamic range is *pp - mp*.

SW209



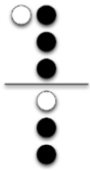
i/  OR  *pp - ff*

ii/  OR  *pp - mf*

SW209 consists of two exercises, i/ and ii/. Exercise i/ is in G major and consists of two staves. The first staff (i/) has two options: a triad of G4, B4, D5 and a dyad of G4, B4. The second staff (ii/) has two options: a triad of B3, D4, E4 and a dyad of B3, D4. Exercise ii/ is in G major and consists of two staves. The first staff (i/) has two options: a triad of G4, B4, D5 and a dyad of G4, B4. The second staff (ii/) has two options: a triad of B3, D4, E4 and a dyad of B3, D4. The dynamic range is *pp - mf*.

SW210

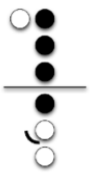
i/ OR *pp - f*



ii/ OR *pp - mp*

SW211

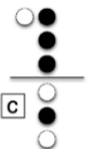
i/ OR *pp - mf*



ii/ OR *pp - mp*

SW212

i/ OR *p*



ii/ OR *p - mp*

SW213

i/ OR *f*

ii/ OR *f*

SW214

i/ OR *pp - mp*

ii/ OR *pp - mp*

SW215

i/ OR *p - mp*

ii/ OR *mp - ff*

SW216

i/ OR *pp - mp*

ii/ OR *pp - mp*

SW217


i/ OR *pp*


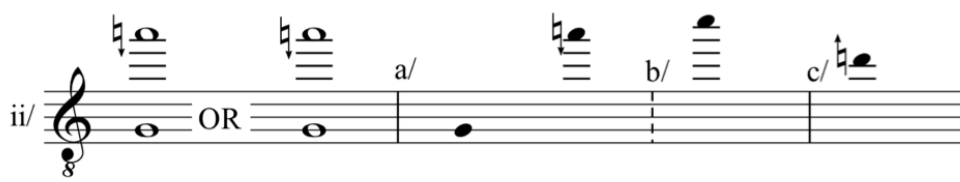
ii/ OR *pp - mp*

SW218

i/ OR *pp - mp*

ii/ OR *mf - ff*

**SW219**


i/  *pp - p*  
 ii/  *pp - p*

**SW220**


i/  *p - mp*  
 ii/  *p - mf*

**SW221**


i/  *pp - mp*  
 ii/  *pp - f*

SW222

i/ OR *pp - p*

ii/ OR *pp - p*

SW223

i/ OR *pp - mp*

ii/ OR *pp - f*

SW224

i/ OR *pp - f*

ii/ OR *pp - ff*

SW225




i/ OR *pp - p*

ii/ OR *pp - mp*

Detailed description: This block contains two musical exercises, i/ and ii/. Exercise i/ is in G major and consists of two staves. The first staff shows a sequence of chords: G major (open), G major (first position), A major (first position), B major (first position), and C major (first position). The second staff shows the same sequence with a different voicing. Exercise ii/ is in G major and also consists of two staves. The first staff shows: G major (open), G major (first position), A major (first position), B major (first position), and C major (first position). The second staff shows: G major (open), G major (first position), A major (first position), B major (first position), and C major (first position). A hand position diagram to the left shows the first and second positions of the right hand on the strings.

SW226



i/ OR *p - mp*

ii/ OR *p - mf*

Detailed description: This block contains two musical exercises, i/ and ii/. Exercise i/ is in D major and consists of two staves. The first staff shows: D major (open), D major (first position), A major (first position), B major (first position), and C major (first position). The second staff shows: D major (open), D major (first position), A major (first position), B major (first position), and C major (first position). Exercise ii/ is in D major and consists of two staves. The first staff shows: D major (open), D major (first position), A major (first position), B major (first position), and C major (first position). The second staff shows: D major (open), D major (first position), A major (first position), B major (first position), and C major (first position). A hand position diagram to the left shows the first and second positions of the right hand on the strings.

SW227



i/ OR *pp - p*

ii/ OR *p - f*


Detailed description: This block contains two musical exercises, i/ and ii/. Exercise i/ is in D major and consists of two staves. The first staff shows: D major (open), D major (first position), A major (first position), B major (first position), and C major (first position). The second staff shows: D major (open), D major (first position), A major (first position), B major (first position), and C major (first position). Exercise ii/ is in D major and consists of two staves. The first staff shows: D major (open), D major (first position), A major (first position), B major (first position), and C major (first position). The second staff shows: D major (open), D major (first position), A major (first position), B major (first position), and C major (first position). A hand position diagram to the left shows the first and second positions of the right hand on the strings.



SW228

i/ OR *pp - mp*

ii/ OR *pp - ff*

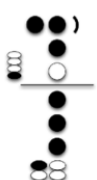


Detailed description: This block contains two musical staves for exercise SW228. The first staff, labeled 'i/', shows two alternative fingerings for a sequence of notes: a/ (A4), b/ (B4), and c/ (C5). The first fingering uses fingers 1, 2, and 3, while the second uses 2, 3, and 4. The dynamic range is marked as *pp - mp*. The second staff, labeled 'ii/', shows two alternative fingerings for a sequence of notes: a/ (A4), b/ (B4), and c/ (C5). The first fingering uses fingers 2, 3, and 4, while the second uses 3, 4, and 5. The dynamic range is marked as *pp - ff*. To the left of the staves is a fingering diagram showing a vertical line with circles representing fingers 1-5, with a bracket indicating a specific fingering pattern.

SW229

i/ OR *pp - mp*

ii/ OR *pp - ff*



Detailed description: This block contains two musical staves for exercise SW229. The first staff, labeled 'i/', shows two alternative fingerings for a sequence of notes: a/ (A4), b/ (B4), and c/ (C5). The first fingering uses fingers 1, 2, and 3, while the second uses 2, 3, and 4. The dynamic range is marked as *pp - mp*. The second staff, labeled 'ii/', shows two alternative fingerings for a sequence of notes: a/ (A4), b/ (B4), and c/ (C5). The first fingering uses fingers 2, 3, and 4, while the second uses 3, 4, and 5. The dynamic range is marked as *pp - ff*. To the left of the staves is a fingering diagram showing a vertical line with circles representing fingers 1-5, with a bracket indicating a specific fingering pattern.

SW230


i/ OR *mp*

ii/ OR *mf - ff*



Detailed description: This block contains two musical staves for exercise SW230. The first staff, labeled 'i/', shows two alternative fingerings for a sequence of notes: a/ (A4), b/ (B4), and c/ (C5). The first fingering uses fingers 1, 2, and 3, while the second uses 2, 3, and 4. The dynamic range is marked as *mp*. The second staff, labeled 'ii/', shows two alternative fingerings for a sequence of notes: a/ (A4), b/ (B4), and c/ (C5). The first fingering uses fingers 2, 3, and 4, while the second uses 3, 4, and 5. The dynamic range is marked as *mf - ff*. To the left of the staves is a fingering diagram showing a vertical line with circles representing fingers 1-5, with a bracket indicating a specific fingering pattern.

SW231



i/ OR *p - mp*

ii/ OR *p - mp*

Detailed description: This block contains two musical exercises for SW231. Exercise i/ consists of two staves. The first staff shows a sequence of chords: a triad of G4, B4, D5 (marked with a flat), a triad of A4, C5, E5, a single note A4, a triad of B4, D5, F5, a single note B4, and a triad of C5, E5, G5. The second staff shows a sequence of chords: a triad of G4, B4, D5 (marked with a flat), a triad of A4, C5, E5 (marked with a flat), a single note A4 (marked with a flat), a triad of B4, D5, F5 (marked with a flat), a single note B4, and a triad of C5, E5, G5. Exercise ii/ also consists of two staves. The first staff shows a sequence of chords: a triad of G4, B4, D5 (marked with a flat), a triad of A4, C5, E5 (marked with a flat), a single note A4 (marked with a flat), a triad of B4, D5, F5 (marked with a flat), a single note B4, and a triad of C5, E5, G5. The second staff shows a sequence of chords: a triad of G4, B4, D5 (marked with a flat), a triad of A4, C5, E5 (marked with a flat), a single note A4 (marked with a flat), a triad of B4, D5, F5 (marked with a flat), a single note B4, and a triad of C5, E5, G5.

SW232

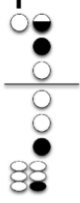


i/ OR *pp - p*

ii/ OR *pp - f*

Detailed description: This block contains two musical exercises for SW232. Exercise i/ consists of two staves. The first staff shows a sequence of chords: a triad of G4, B4, D5 (marked with a flat), a triad of A4, C5, E5 (marked with a flat), a single note A4, a triad of B4, D5, F5 (marked with a flat), a single note B4, and a triad of C5, E5, G5. The second staff shows a sequence of chords: a triad of G4, B4, D5 (marked with a flat), a triad of A4, C5, E5 (marked with a flat), a single note A4 (marked with a flat), a triad of B4, D5, F5 (marked with a flat), a single note B4, and a triad of C5, E5, G5. Exercise ii/ also consists of two staves. The first staff shows a sequence of chords: a triad of G4, B4, D5 (marked with a flat), a triad of A4, C5, E5 (marked with a flat), a single note A4 (marked with a flat), a triad of B4, D5, F5 (marked with a flat), a single note B4, and a triad of C5, E5, G5. The second staff shows a sequence of chords: a triad of G4, B4, D5 (marked with a flat), a triad of A4, C5, E5 (marked with a flat), a single note A4 (marked with a flat), a triad of B4, D5, F5 (marked with a flat), a single note B4, and a triad of C5, E5, G5.

SW233




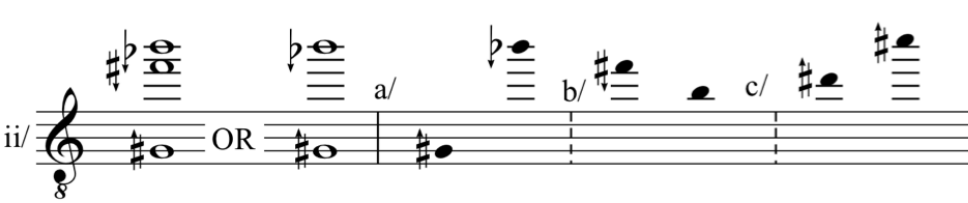
i/ OR *mp*

ii/ OR *mp - mf*

Detailed description: This block contains two musical exercises for SW233. Exercise i/ consists of two staves. The first staff shows a sequence of chords: a triad of G4, B4, D5 (marked with a flat), a triad of A4, C5, E5 (marked with a flat), a single note A4, a triad of B4, D5, F5 (marked with a flat), a single note B4, and a triad of C5, E5, G5. The second staff shows a sequence of chords: a triad of G4, B4, D5 (marked with a flat), a triad of A4, C5, E5 (marked with a flat), a single note A4 (marked with a flat), a triad of B4, D5, F5 (marked with a flat), a single note B4, and a triad of C5, E5, G5. Exercise ii/ also consists of two staves. The first staff shows a sequence of chords: a triad of G4, B4, D5 (marked with a flat), a triad of A4, C5, E5 (marked with a flat), a single note A4 (marked with a flat), a triad of B4, D5, F5 (marked with a flat), a single note B4, and a triad of C5, E5, G5. The second staff shows a sequence of chords: a triad of G4, B4, D5 (marked with a flat), a triad of A4, C5, E5 (marked with a flat), a single note A4 (marked with a flat), a triad of B4, D5, F5 (marked with a flat), a single note B4, and a triad of C5, E5, G5.


SW234

i/  *pp - mp*

ii/  *pp - mf*




SW235

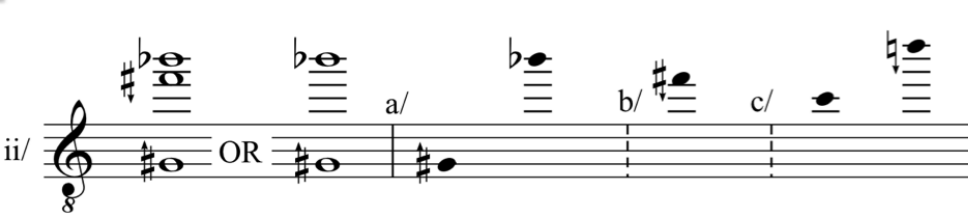
i/  *mp*


ii/  *mp - mf*



SW236

i/  *pp - mf*

ii/  *mf*



SW237

i/ *pp - mf*

ii/ *p - f*

Diagram:

SW238

i/ *pp - mp*

ii/ *pp - p*

Diagram:

SW239

i/ *pp - mp*

ii/ *p - f*

Diagram:

**SW240**

i/ OR a/ b/ c/ - *pp - p*



ii/ OR a/ b/ c/ *pp - mp*

**SW241**

i/ OR a/ b/ c/ *p*



ii/ OR a/ b/ c/ *p - f*

**SW242**

i/ OR a/ b/ c/ *pp - p*



ii/ OR a/ b/ c/ *pp - f*

SW243

i/ OR *pp - mp*

ii/ OR *pp - mf*

SW244

i/ OR *pp - mp*


ii/ OR *pp - mf*

SW245

i/ OR *pp - mp*

ii/ OR *pp - mf*

SW246

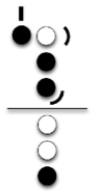
i/  *pp - mp*



ii/  *pp - mf*


SW247

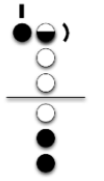
i/  *pp - mp*




ii/  *pp - f*

SW248

i/  *pp - p*



ii/  *pp - f*

SW249

i/ *p - mp*

ii/ *pp - f*

Detailed description: This block contains two musical staves for exercise SW249. The first staff, labeled 'i/', is in treble clef with a key signature of one sharp (F#). It features a sequence of chords: a triad (F#, A, C), a dyad (F#, A), a dyad (A, C), a dyad (F#, C), and a triad (F#, A, C). The second staff, labeled 'ii/', is in the same key signature and features a sequence of chords: a triad (F#, A, C), a dyad (F#, A), a dyad (A, C), a dyad (F#, C), and a triad (F#, A, C). To the left of the staves are two vertical fingering diagrams. The first diagram shows fingerings for the first staff, and the second diagram shows fingerings for the second staff. The diagrams use solid black dots for fingers and open circles for the thumb.

SW250

i/ *p*

ii/ *p - mf*

Detailed description: This block contains two musical staves for exercise SW250. The first staff, labeled 'i/', is in treble clef with a key signature of one sharp (F#). It features a sequence of chords: a triad (F#, A, C), a dyad (F#, A), a dyad (A, C), a dyad (F#, C), and a triad (F#, A, C). The second staff, labeled 'ii/', is in the same key signature and features a sequence of chords: a triad (F#, A, C), a dyad (F#, A), a dyad (A, C), a dyad (F#, C), and a triad (F#, A, C). To the left of the staves are two vertical fingering diagrams. The first diagram shows fingerings for the first staff, and the second diagram shows fingerings for the second staff. The diagrams use solid black dots for fingers and open circles for the thumb.

SW251

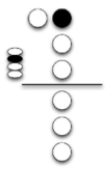
i/ *p - mf*

ii/ *p - mf*

Detailed description: This block contains two musical staves for exercise SW251. The first staff, labeled 'i/', is in treble clef with a key signature of one sharp (F#). It features a sequence of chords: a triad (F#, A, C), a dyad (F#, A), a dyad (A, C), a dyad (F#, C), and a triad (F#, A, C). The second staff, labeled 'ii/', is in the same key signature and features a sequence of chords: a triad (F#, A, C), a dyad (F#, A), a dyad (A, C), a dyad (F#, C), and a triad (F#, A, C). To the left of the staves are two vertical fingering diagrams. The first diagram shows fingerings for the first staff, and the second diagram shows fingerings for the second staff. The diagrams use solid black dots for fingers and open circles for the thumb.



SW252

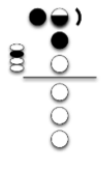


i/ OR *pp - p*

ii/ OR *p - f*

Detailed description: This block contains two musical staves for exercise SW252. The first staff, labeled 'i/', shows a sequence of chords: a triad of G4, A4, B4, followed by a dyad of G4, A4, then a dyad of G4, B4, and finally a triad of G4, A4, B4. The second staff, labeled 'ii/', shows a sequence of chords: a triad of F4, G4, A4, followed by a dyad of F4, G4, then a dyad of F4, A4, and finally a triad of F4, G4, A4. Hand diagrams are provided to the left of each staff, showing fingerings for the right hand (circles) and left hand (dots).

SW253




i/ OR *pp - p*

ii/ OR *pp - p*

Detailed description: This block contains two musical staves for exercise SW253. The first staff, labeled 'i/', shows a sequence of chords: a triad of G4, A4, B4, followed by a dyad of G4, A4, then a dyad of G4, B4, and finally a triad of G4, A4, B4. The second staff, labeled 'ii/', shows a sequence of chords: a triad of F4, G4, A4, followed by a dyad of F4, G4, then a dyad of F4, A4, and finally a triad of F4, G4, A4. Hand diagrams are provided to the left of each staff, showing fingerings for the right hand (circles) and left hand (dots).

SW254



i/ OR *pp - p*

ii/ OR *mf - ff*

Detailed description: This block contains two musical staves for exercise SW254. The first staff, labeled 'i/', shows a sequence of chords: a triad of G4, A4, B4, followed by a dyad of G4, A4, then a dyad of G4, B4, and finally a triad of G4, A4, B4. The second staff, labeled 'ii/', shows a sequence of chords: a triad of F4, G4, A4, followed by a dyad of F4, G4, then a dyad of F4, A4, and finally a triad of F4, G4, A4. Hand diagrams are provided to the left of each staff, showing fingerings for the right hand (circles) and left hand (dots).

SW255

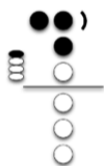
i/ OR a/ b/ c/ *pp - mf*



ii/ OR a/ b/ c/ *mp - f*

SW256

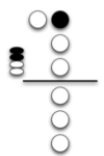
i/ OR a/ b/ c/ *pp - mf*



ii/ OR a/ b/ c/ *pp - mf*

SW257

i/ OR a/ b/ c/ *pp - mf*



ii/ OR a/ b/ c/ *pp - mf*

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## Appendix 2

**CD1** is a data CD. It contains three folders of audio and graphic files:

**Type One audio (chapter three)** – This folder contains audio samples for the bassoon's and bass clarinet's lowest notes, plus Type One multiphonics and their variants that are analysed in this chapter.

**Data CD; SW Charts; audio MP3** – This folder contains audio files for each multiphonic in the SW charts. This folder should be used in conjunction with the charts in Appendix 1.

**Data CD; SW Charts; graphics** - – This folder contains graphic tiff files for each multiphonic in the SW charts. This folder should be used in conjunction with the charts in Appendix 1. The author gives permission for these graphics to be used and imported into compositional software.

**CD2** is an audio CD of a selection of works that were composed using the results of this research.

Tracks 1 - 8 were recorded in May 2013, in St. Helen's Church, Burton Joyce, Nottinghamshire. Produced and recorded by Laurence Perkins; edited by Sarah Watts

Track 1: <i>quarter-sounds</i> for solo bass clarinet (2012)	Marc Yeats	08:34
Track 2: <i>Geometry of Air</i> for solo bass clarinet (2012)	Ian Matheson	04:36
Track 3: <i>Airway</i> for solo bass clarinet (2012)	Gareth Churchill	04:20
Track 4: <i>Sybil</i> for solo bass clarinet (2012)	Antony Clare	04:55
Track 5: <i>Mi cantare!</i> for solo bass clarinet (2012)	Miroslav Spasov	05:26
Track 6: <i>Three Days on the Road</i> for solo bass clarinet (2012)	Sohrab Uduman	04:13
Track 7: <i>Multiphonic Study</i> for bass clarinet (2012)	Victor Baez	06:05
Track 8: <i>Screapadal</i> for solo bass clarinet (2012)	Sarah Watts	13:00

Track 9: *Her Sisters' Notebook* for bass clarinet and tape (2011) Lola Perrin 07:34

Excerpt only

Live recording from the premiere. Peninsula Arts, Plymouth. February 2012

Track 10: *Pareidolia*, for sensor-enhanced bass clarinet (2012) Patrick Nunn 02:04

Excerpt only.

Recorded at the Royal Academy of Music, May 2012. Producer and editor Patrick Nunn. Thank you to Patrick Nunn for permission to use this extract.

Track 11: *Darkness Visible* for bass clarinet and piano (2012) George Nicholson 02:52

Excerpt only

Recorded at Keele University, July 2012. Producer and editor Laurence Perkins.

Full recording released on *Timeless Shades*, by SCAW; Cuillin Sound Label.

CUILL2002 - [www.cuillinsoundmusic.co.uk](http://www.cuillinsoundmusic.co.uk)

Thank you to Cuillin Sound for permission to use this excerpt

Track 12: *Timeless Shades of Green* for bass clarinet and piano (2012)

Stephen Davismoon 02:28

Excerpt only

Recorded at Keele University, July 2012. Producer and editor Laurence Perkins.

Full recording released on *Timeless Shades*, by SCAW; Cuillin Sound Label.

CUILL2002 - [www.cuillinsoundmusic.co.uk](http://www.cuillinsoundmusic.co.uk)

Thank you to Cuillin Sound for permission to use this excerpt.

Sarah would like to thank Keele University and St. Helen's Church, Burton Joyce, for the use of the venues for the recording of the multiphonics in CD1, the études in CD2 and for the *Timeless Shades* CUILL2002 disc.

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