

Actions and Sounds

An Introduction to *Cello Map*

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IDENTIFYING A PROBLEM IN PERFORMANCE PRACTICE

Many musicians in the field of contemporary music have identified a basic problem: a confusion surrounding the numerous instrumental techniques developed over the last half-century. The instrumentalists' means to control these new techniques is not practised within traditional instrumental training. Knowledge outside this training is required. What kind of information can help in establishing a new technical training, and what is the best way to present this to instrumentalists/composers? What are the roots of the problem relating to newly developed techniques?

Later in this essay, I will identify unclear terminology as a contributing factor in misunderstandings regarding new instrumental techniques. Firstly, let us clarify the definition of the word «technique» itself. Instrumental technique can be defined simply as sound modifying actions made by an instrumentalist. However, it is important to state clearly: technique is not fixed. Musicians usually use the word technique as a measure of ability (it is not fixed because it can be improved). Moreover, technique has changed considerably through time: technique has a history. Cello technique developed throughout the last two centuries to include, for example, thumb position, *spiccato* bowing, vibrato, use of an end pin, etc. So, despite the surge of additions made in the twentieth century, the idea of

developing technique is itself not new or surprising. There is a body of literature documenting technical development, and there are study or exercise books that support instrumentalists.

Historically, etudes and exercises have introduced new aspects of technique as they have entered the canon, and been used to refine established techniques. Many such studies have maintained their relevance; books by Grützmacher¹, Popper² and Feuillard³ are still valuable resources for cellists. There are relatively few modern study books that attempt to prepare students to play contemporary music. Two notable exceptions for cellists are: Caroline Bosanquet's book (dedicated to harmonics⁴) and a collection of extracts to be used as studies to modern cello playing compiled by Siegfried Palm.⁵ The Palm studies are part of a series, *Pro musica nova*, by Breitkopf und Härtel, that includes similar books for flute, piano, oboe, violin, viola, guitar, and clarinet. A recent important addition to the string players' literature are Garth Knox's studies for violists on eight particular aspects of technique (*sul ponticello, sul tasto, glissando, pizzicato, tremolo, harmonics, quartertones, bow directions*).⁶ The handful of available studies regarding modern technique is surprisingly limited in number considering the amount of innovations that appeared since the 1960s. Of course, many method books are still being published, but the vast majority of these are new approaches to traditional technique, often with a specific pedagogical

focus. Historically, examples exist that document new techniques being described for the first time. The following two examples open up the problem and briefly illustrate that the matter of dealing with new technique doesn't exclusively belong to our generation. In the following passage, legato bowing on the viol is newly introduced to a performer readership of 1620. It is interesting to see how an aspect of technique that is now fundamental to string players was defined and illustrated as a new method for the first time:

«By legato bowing we mean playing two, three, or more notes in a single bow stroke [...] It is necessary for the wrist of the bow hand, almost jumping, to beat each note, one at a time [...] You should be careful not to make more noise with the bow than with the sound.»⁷

Articulating, rather than practically approaching, the problem of «newness», Berlioz wrote in his *Treatise on Instrumentation* of 1844:

«In the future the *pizzicato* will doubtless be used in even more original and attractive effects than here to fore. Violinists, not considering the *pizzicato* an integral part of violin technique, have given it hardly any serious attention... Players will doubtless become familiar with [a wider range of] techniques in the course of time. Then composers will be able to take full advantage of them.»⁸

Composers' research into new instrumental techniques has traditionally been supported by instrumentation and notation guides, which are still prolifically published today. However, the modern approach to describing new techniques has given rise to a new genre of literature that combines instrumentalists' methods with composers' notation and instrumentation guides: the handbook of instrumental technique. This is the category of literature that my research also falls into.

The earliest example that I have found of such a handbook is Carlos Salzedo's harp method that combines text and etudes. Writing in 1921, Salzedo describes: plucking the strings so forcefully that they strike one another, striking the sound board, sliding the tuning key along a vibrating string to change its pitch, preparing the harp with paper, etc. Another pioneering figure in writing handbooks on instrumental technique is Bruno Bartolozzi, the first to write in detail about multiphonics and microtonal playing in woodwind instruments in *New Sounds for Woodwind*, first published in 1967. There are two major series: the *New Instrumentation Series of Handbooks on Modern Instrumental Technique* by University of California Press (so far for double bass, flute, trombone, clarinet, guitar, harp, violin, oboe, voice) and the Bärenreiter series (so far for oboe, flute, saxophone, bassoon and accordion). The Bärenreiter series is particularly recommended. There are also several independent publications (Robert Dick's *The Other Flute* is a notably pioneering book in categorising multiphonics). See the bibliography on p. 97 for a reference list.

What can we (performers and composers) expect from such books? What makes such a book useful? In reviewing the literature I found structure and content to be equally important qualities. I will use some examples from the literature to illustrate both positive and negative approaches to structure and content.

Structure

Structure (layout and categorisation of information) is hugely important to books that are not intended to be read from start to finish, but rather as reference guides to access the answer to a particular question. The structure of most handbooks groups information by methods, which are usually defined by sound (for example common chapter headings are: *glissando*, the prepared instrument, percussive sounds, harmonics, multiphonic sounds, etc.). This layout is displayed on the contents page, upon which the accessibility and therefore usefulness of such a book heavily rests. Sometimes chapter headings in contents pages can be found that might stem from interesting ideas but are almost impossible for the reader to understand when in search for a particular information (e.g. Time Envelope, Spectral Envelope, Formant Glide, Airflow, Extremes...).

Further problems appear when headings and subheadings are not given relative weight, when the same aspects of technique appear more than once in the contents page, or when overlaps in information occur, leading the reader to several passages in pursuit of a single piece of information. For example: If *col legno battuto* is categorised under «Bowing Technique» and «Percussion Techniques» will the information in the text simply be repeated? If «The Fingers» and «Percussion Techniques» are separate chapter headings, which chapter will contain information about striking the string with the fingers?

Many of the books in the literature have a chapter titled «miscellaneous techniques» (or similar), i.e. there is a group of techniques that do not fall into the categorisation laid out on the contents page. Since such books are not generally read from start to finish, but rather used as reference material, or as a dictionary, to look up a specific problem, there is a danger that information categorised as «miscellaneous techniques» will never be considered by the reader.

To summarise: a «reader-friendly» structure, which is of paramount importance to a dictionary-style resource, has not been standardised, not even prioritised, in the literature. Furthermore, information has often been categorised inconsistently or not clearly enough.

Content

Descriptions of instrumentalists' actions/methods and the resulting sound are presented in the literature alongside suggested notations and illustrative citations from compositions. Various levels of explanation behind principles of technique can be successfully invoked, from experience-based theory (tips and observations «proven» through experience) to deeper, research based acoustics (the physical reason why a fact is true). Consider the following examples:

«[In order to produce a multiphonic] it often helps to abandon normal embouchure position, to take (much) less mouthpiece and [...] reduce the embouchure pressure.»⁹

«[The angle of the flute] primarily affects pitch; as the angle of the flute is turned inwards towards the player, the pitch is lowered...Turning the flute in tends to increase the strength of the higher partials in the tone and weaken the fundamental.»¹⁰

Despite the difference in depth of reasoning, the above examples are useful in showing clearly how an instrumentalist can influence sound. Problems of understanding occur when a proper connection between the performer's actions and sound is not made clear (and this independently of the amount of acoustical information additionally given). Compare the following examples with those above. The reader is left asking himself: Why? How? What does that sound like?

«Right hand plucking technique can alter the tone quality of harmonics.»¹¹

«[Overblowing] has the greatest effect on low notes.»¹²

An insufficient connection to sound is apparent in the literature in another sense. This can be characterized as a lack of continuity. I define it as «the catalogue problem»: listing techniques without making comparisons or connections between them or their resulting sounds. This can be seen at its most extreme in the following example from a notation/technique guide describing percussive devices in the violin family:

- «1. Slap/strike the strings with the flat left-hand fingers over the fingerboard [...]
2. Same, with the fingers over the bridge [...]
3. Tap the strings with the fingers [...]
4. Trill on the strings with the left-hand fingers (no bow) [...]

There are twenty-two entries in this list, followed by: «devices mainly applicable to violoncello and/or contrabass»:

- «1. Slap the four strings with the left-hand fingers near to or on the instrument neck [...]
11. With a large wooden salad-tossing spoon in the left hand, strike the strings behind the bridge [...]
12. Same, with a tablespoon [...]
16. Same, with a chopstick [...]»¹³

Despite the length of the list, the information that the reader might retain from this passage is limited. Indeed, the resulting sound is not described, and possible variations on technique outside this list not considered (how much simpler and more

informative would be the statement: the denser the object with which the string is struck, the more overtone-rich the sound?).

A further problem in listing techniques appears when illogical subdivisions are made. Consider the following summary of points of contact on a violin string:

«The points of generation are:

1. Bow placed more or less half way between the bridge and the fingerboard, or position *normale*.
2. Bow placed near or on the bridge: *sul ponticello*.
3. Bow placed between the bridge and the tailpiece: *sub ponticello*.
4. Bow placed under the strings.
5. Bow placed over the fingerboard: or *sul tasto*.
6. Bow placed on the non-resonating part of the strings, between left hand fingers and nut.
7. Bow placed in the peg box or on the body.»¹⁴

The authors group bowing on a string and bowing on wood in numbers two and seven but choose to separate points one, two and five unnecessarily, since contact can take place at any point on the string length, suggesting that three discrete points exist that elude the continuous scale present on the instrument. A more useful explanation of point of contact would describe the way in which overtone content changes as contact point moves along the whole string length, or, separately, at different parts of the violin body.

The catalogue problem can be summarised as providing too much of one kind of information – unnecessarily subdividing («oversubdividing») technique –, and too little of another – not supplying enough information, omitting references to the resulting sound. In so doing, the author describes one instance of a technique, but does not give an impression of the parameters of an instrumentalist's actions and how these actions relate to and alter the resulting sound. In other words, catalogue-style information is disposable; it can be used once to recreate a technique but is not sustainable as new techniques are developed. Techniques become «one-off» special effects.

Catalogue-type information, however, has certain advantages over other approaches: it is fast and easy to assimilate and to digest. Generating a list of previously used techniques and notations is easy and practicable (it can be done via Google), especially if a representative list (rather than a comprehensive one) is drawn up. Representative lists can show bias towards certain compositional schools or individuals, which might be most favourable to the composer/performer authorship. From a reader's perspective, the quick and easy access to an answer is, of course, attractive. However, in my opinion, the combined disadvantages far outweigh the advantages and create the risk of overlooking a deeper, «reusable» understanding of technique. Moreover, describing technique without showing bias towards certain compositional schools provides a more universally accessible and practical basis for further investigation.

Notation and terminology; extensions of the «catalogue problem»

In a sense, notation has contributed to an atmosphere of isolated special effects. By this I mean that notation has helped to conceal variation of sound in particular techniques. For example, for each of the following techniques a single notation is usually employed: *Bartók pizzicato*, a tone bowed with overpressure and tapping the instrument body. How much musical variation would an instrumentalist consider possible in these techniques? As an instrumentalist, how would you comply if a *Bartók pizzicato* were marked *sostenuto*? If a tone bowed with overpressure were marked *piano*? If tapping the instrument body were marked *overtone-rich*?

A further problem is the use of terminology that surrounds the idea of technique. The recent emergence of the term «extended technique» points to an inconsistency in the ideology surrounding technique. Describing some techniques as «extended» or «modern» implies being able to distinguish them clearly from «non-extended» or «standard». Such a task is difficult as it is often impossible to draw an unambiguous line between the two: when, for instance, does decreased bow pressure go beyond *flautando*? When does «fast *vibrato*» become «exaggerated *vibrato*»? How precise a sub-categorisation of *sul ponticello* or *sul tasto* can be labelled «extended» («extreme *sul tasto*», «one centimetre from the bridge» or «on the bridge»)? Categorising techniques as outside the canon also creates contradictions in a historical sense.

Examples from composers as diverse as Heinrich Ignaz Franz Biber (in preparing a double bass string with paper), Claudio Monteverdi (in developing, probably inventing *tremolo* on stringed instruments), Niccolò Paganini (in writing high harmonics) and Gustav Mahler (in using *col legno*) demonstrate an «extension» of the conventional playing of their time that predates the terminology.

This fracturing of technique through terminology is closely linked to the catalogue problem defined above: techniques have been divided and organised under frameworks that do not exist. The context of newly developed techniques is obscured. The extent to which performers can apply traditional technical practice to new methods is unclear.

THE RESOURCE «CELLO MAP»

In my approach *Cello Map*¹⁵, previously catalogued techniques are described as belonging to a single method or family of methods. The theoretical importance of my proposal is: if it is possible to imagine a hypothetically complete space of «every sound that can be produced on the cello», then outside past and present techniques are «undiscovered» techniques, or «improper» playing that are yet to be treated musically, i.e. there is a space to develop technique in a logical way and in the context of what we already know. In reality, all technique is conditioned by the physical abilities of the performer and the instrument, and this is the «true» limit on technique. Technical development (historical and personal) can then be understood

as taking place within this «real» potential space. To move from this theoretical ideal to a practical approach I asked myself the following key research questions:

- Can cello technique as a whole be reduced to a minimum number of actions?
- Is it possible to organise the variation of these actions upon a continuum (a set of continuous «scales») and link this to scales of sound (increasing and decreasing magnitudes of pitch, loudness, and overtone content)?
- If so, can we define the parameters and suggest the limits of these scales, i.e. explore the scope of an action (the range in loudness, pitch and overtone content that are available to the cellist)?

This approach views unusual techniques in the same (essentially musical) way that we view traditional techniques, asking, for example: how loudly can I play this? What happens if I increase bow pressure? What are the differences in high and low positions? Regarding traditional techniques, this might seem overly analytical, it might seem to make a process of something which is natural/instinctive (for example: I can increase the loudness of a *pizzicato* tone by increasing the force of my plucking finger, or: I can increase the overtones in the timbre of a bowed tone by moving the point of contact towards the bridge). Technique is discussed in this way in the early stages of learning an instrument. For new techniques such an application seems appropriate, because we are also learning them for the first time.

The key to realising the proposed continuity is, firstly, the reduction of technique. Here I mean to imply that technique is a group of parameterised actions and that, since the parameters of action are continuous, they can be organised on scales, which have natural limits. Any part of technique that can be assigned to the same scale is part of the same particular parameter of action. For example, the action of exciting a string (by bowing, plucking or striking it) is parameterised by the point of contact, which is located between the limits of the bridge and the nut. Similarly, the parameter of excitation force is bound by the minimum and maximum force that a particular arm can apply.

The second process in the organisation of technique is mapping cellists' actions to sound. Here I mean mapping in the mathematical sense: relating two sets (in this case the theoretically complete spaces: «actions possible on the cello» and «sound that a cello can produce») by linking the objects (actions and sounds) within them. This is the key idea of my research: to create a cello «map». Since each parameter of action is continuous, the relation action-sound can be described on a scale. For example: point of contact is proportional to the number of overtones present in the resulting sound; excitation force is proportional to loudness. While the parameters of the actions, the inputs, are continuous, the resulting sound, the outputs, need not be. For example: as contact point moves towards the bridge (continuously), overtone content becomes richer, then at a certain point lower partials begin to drop out of the sound. Or: as excitation force increases (continuously), loudness increases, then the

increase reduces and eventually the sound becomes distorted. Similarly, as left hand finger pressure reduces, overtone content and decay duration also reduce. Eventually, harmonics are introduced into the sound, the overtone content and decay duration of which relate in the opposite way to finger pressure. Harmonic pitch is also influenced by finger pressure. At very low pressures, multiphonics and the sound of the open string prevail.

The following examples show how I represented the various parameters described above graphically in *Cello Map*. The figures require some contextualisation which is provided in the surrounding text of *Cello Map* (for example a more indepth description of the term «Overtone Takeover»). The reader is invited to consider the way of representing the information as a mapping between action and sound (Figure 1, Figure 2, Figure 3).

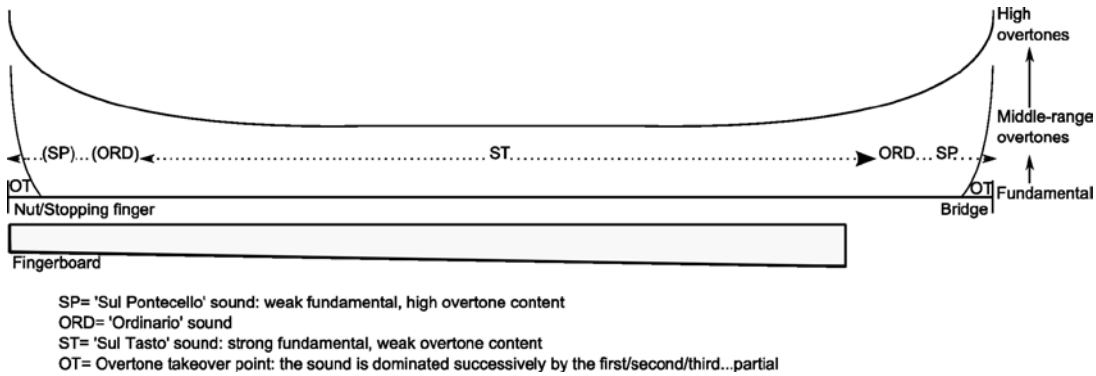


Figure 1: The overtone content for contact points along the whole string length. The cello string is represented by the horizontal line directly above the fingerboard. The curves above the string represent the number and relative loudness of the overtones that contribute to the resulting sound relative to contact point.

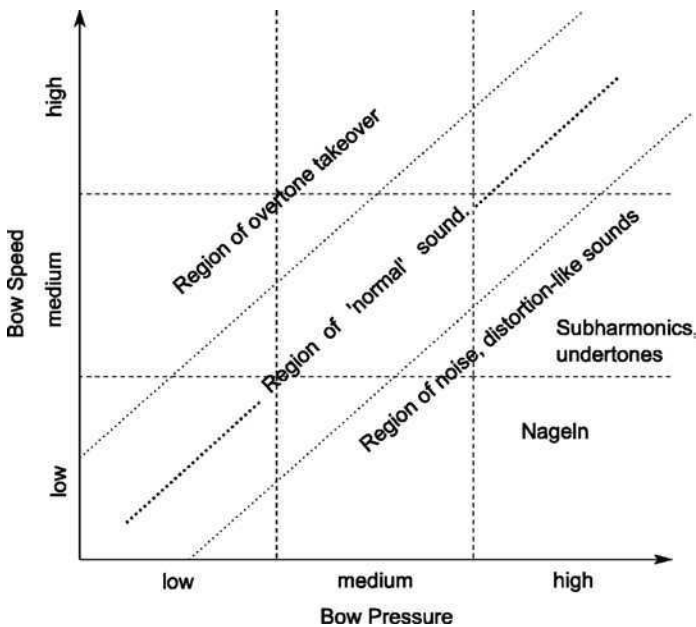


Figure 2: The bow speed-pressure vector: The relationship between bow speed and pressure are represented in this diagram.

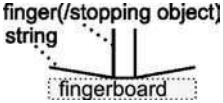

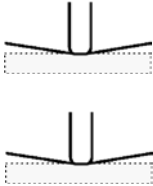
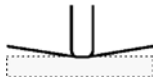
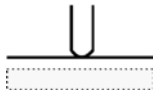
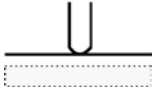
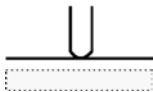
	Finger pressure	Output
	Using the finger nail/ other dense object. Very high pressure	Overtone-rich sound, high duration
		Gradual reduction in overtone content and duration
	Normal pressure	'Normal' sound
		Stopped string pitch with low overtone content and harmonic (possibly slightly sharp). The harmonic becomes louder relative to the stopped pitch as pressure decreases.
	High harmonic pressure	Sharp harmonics with reduced overtone content
	'Ordinary' harmonic pressure	In-tune harmonics
	Low harmonic pressure	In-tune harmonics with high overtone content
	Very light pressure	Multiphonics: mixture of two or more harmonics and possibly increased 'noise' component and/or the open string pitch is heard with the harmonic. The amplitude of the open string increases relative to that of the harmonic as pressure reduces. The stopped string pitch might also be faintly present.

Figure 3: A scale of finger pressure variation.

My reduction of cello technique in terms of actions, associated parameters and sound can be exposed as follows:

Input: Actions and their parameters

Actions that generate vibration:

- Plucking (with a plectrum, traditionally the right-hand fingers)
- Striking (with a hammer, traditionally the wood of the bow)
- Bowing or stroking (with any bowing object, traditionally the bow)

Actions that interfere with the vibration (before/after it has been generated):

- Stopping/touching the strings (shortening the string or harmonics)
- Allowing external elements to absorb vibration (mutes, preparations, rattles)

Parameters:

- Point of excitation/interference:
 - The cello strings between nut and bridge, between bridge and tailpiece (including the wrapped part of the string) and in the peg box
 - The cello body/bridge/tailpiece/pegs/fingerboard (without touching the strings)/end pin
- Force of excitation:
 - Distance of pluck - «pull»
 - Speed of attack or strike
 - Pressure and speed of bow (or alternative object)
- Direction of excitation:
 - Angle of pluck/strike/stroke
- Quality of object which initiates excitation:
 - Width/density of plectrum
 - Width/density of hammer
 - Width/density/tilt/material (i.e. bow hair, wood of bow, fingers) of bowing object
- Tension of strings:
 - Amount by which the string is <stretched> by peg (or other object)
- Nature of interference:
 - Pressure and material of stopping finger (or alternative stopping object)
 - Quality of mute/other external object: width/density and pressure/angle at which it is applied

Musical Output: Sound

- Pitch
- Loudness
- Timbre
- Duration

Viewing technique in such a way shows the simplicity of the idea behind a reduction of technique. The musical output seems especially simple. Of course, using technique in such a way that pitch, loudness, timbre, and duration are musically interesting is not simple, but this is not my task. A useful

handbook, in my opinion, separates technique from musical taste. My aim is to demystify technique: to put taste aside and to explain past methods – previously discussed only in an opinion-based, or «mystifying» way – in both technically and precisely. To show, simply, how a player/composer can influence sound.

The process of connecting parameters of action to parameters of sound is fundamental to realising the proposed cello «map». It required background reading and empirical research in acoustics. Stating the importance of linking action and sound seems so obvious, almost trivial; of course, an instrumentalist should always be aware of his/her influence over sound. An insufficient link between action and sound is a most basic and serious problem, but it is widespread and occurs more frequently in the case of new techniques. The link between actions and sound is acoustics. A basic acoustical understanding is often incorporated in the teaching of a musical instrument. This understanding does not need to be as deep as a scientist's but is nonetheless clear and conscious. In fact, there is a propagation of false information that is remarkably widespread, and part of the problem is an insufficient link between action and sound. For example, Garth Knox, in his recent book of viola studies mentioned above, gives a short introduction to each of the technical themes around which the studies are centred. He uses acoustics to help the player understand the sound but presents some basic misunderstandings:

«The closer the bow plays to the bridge [in *sul ponticello*], the more the high harmonics of the note being played become audible.

[In *sul tasto*] the bow is actually preventing the string from vibrating freely, reducing the high harmonics.

By touching the string lightly with the left hand at strategic points on the string, we can obtain single partials, and these are called harmonics.»¹⁶

The studies in Knox's book are excellent resources. However, the above statements are, scientifically speaking, incorrect. Metaphors and imagery that is often «unscientific» are frequently presented to instrumentalists, sometimes in a helpful way (for example: «for a full sound, imagine that the bow is moving along the centre rather than the surface of the string», «for good intonation, place the centre of the finger at the centre of the string's node»). Is scientific accuracy important if unscientific imagery has the desired effect? No, it is not important for performance, but it can have undesirable influences in the developing of technique in general. Starting from a basis of incorrect information can hinder what is essentially «researching» an instrument.

Practical applications

Naturally, within my method, traditional and new techniques are treated in the same way; they are both part of the global

view: «everything that is possible on the cello». In this sense I am working outside music history, not prioritising, for example, bowed sound because it has been used most often. The strength of fitting new and old techniques into a global technique is the enabling of application of information. I use the terms «plectrum», «hammer» and «bowing object» in a neutral way to open possibilities. The knowledge we have relating to plucking with the finger can also be applied to plucking with a guitar plectrum (e.g. moving towards the middle of the string reduces overtone content); the knowledge we have relating to *col legno battuto* can be applied to *Fingerschlag*, (e.g. the duration of hammer-to-bridge tone is maximised when the hammer is held to the string); the knowledge we have about bowing can be applied to stroking the cello strings with the hands (e.g. the faster the stroke, the louder the resulting sound). In other words this global view exposes ways of influencing sound that might not have been obvious otherwise.

METHODOLOGY

The key steps in my methodology were:

1. Reducing cello technique into actions and developing continuous scales for parameters of these actions
2. Linking action and sound
3. Structuring the information in a consistent and logical way

The reduction of cello technique is described above. The second step, linking these scales of parameters of action to sound, involved background reading in acoustics. Where relevant acoustical information was lacking I undertook empirical research (for example I considered the effect of plucking direction on loudness and overtone content by analysing recordings, and recorded the exact pitch of harmonics two to thirteen and compared this to their expected pitch in terms of the harmonic series) or proposed areas for further study.

To structure my research, I divided the information into four sections with minimum overlaps: Excitation of the String; Harmonics¹⁷; The Prepared Cello and Excitation of the Body, Bridge, Tailpiece and Bow Hair. The parameters of action set the titles of the subheadings («Point of contact», «Force of excitation», etc.) and these are discussed in relation to sound. The actions, «plucking», «striking» and «bowing» are referred to specifically as subheadings if additional information is required. Where extra scientific information exists and might be useful to the understanding of the parameters, a subheading, titled «Explicatio» follows the main text. This is independent to the main text and meant to provide more detailed acoustical information regarding the understanding or techniques. There is no section for miscellaneous or extra techniques; every aspect of sound discussed has a logical place in the global framework.

The text provides an exploratory answer, rather than a direct one, to a question regarding technique. The information links actions and sound with a basis in acoustics. It is a step

back from the score and needs application. Rather than referring to a traditional word-by-word index, the reader navigates within the resource by the means of either an Actions Index, which lists the headings and subheadings as they appear in the text, or a Parameters of Sounds Index, which lists descriptions of the sound outcome in terms of pitch, loudness, overtone content and duration, and refers the reader to the relevant section of text. This double index allows the reader to approach the research with a question about technique/action (e.g. What kind of control do I have over bowed overpressure techniques, and what sounds can I expect to produce?) or with a question about sound (e.g. How can I vary the timbre of a *pizzicato* tone?).

This is to my knowledge the first time that instrumental technique has been treated as a continuum. An investment is required to obtain the acoustical understanding implicit in this approach. However, the idea itself provides a simple solution to the problems presented in this text, which were observed both in the literature and the ideas surrounding technique. These problems (insufficient connection between action and sound, one-off catalogued special effects, notational issues, misconceptions concerning acoustics and contradictions in the debate regarding new instrumental techniques) restrict interpretive freedom. The continuum presents a way of tackling these problems directly, by reopening interpretive freedom. Naturally, organising the actions of a cellist on continuous scales exposes the means of modifying sound by degrees. In so doing, it rejects special effects and expands the possibilities of musical expression. This way of presenting technique provides a framework for further research, which can be taken up and expanded by instrumentalists, composers and acoustics researchers.

PROPOSALS FOR FURTHER RESEARCH

There is much to do to take this research further. As I mentioned above, structure is crucial to the usefulness of such handbooks. I am satisfied with the dual index solution to navigate around *Cello Map* either by action or by sound. However, in a book format this task is cumbersome. In its current format the indices are on separate sheets of paper to minimise the need to constantly turn to the front/back of the book. However, this is not a wholly satisfactory solution. The research suits the webpage format much better; the indices can be returned to with minimum effort and the main text is hidden until it is called up by the link, i.e. the more detailed acoustical «Explicatio» sections can easily be accessed or disregarded depending on the reader's interests. In September 2011 I will begin a project in the Department for Research and Development at the Hochschule für Musik Basel to edit the content of *Cello Map* and transfer it to a webpage format.

Although my approach to cello technique was neutral, the existing acoustical resources for the violin family focus almost entirely on bowed sound, almost always within a traditional technical framework. I was able to adapt some information

from guitar, harpsichord, piano, and clavichord acoustics but much of the supporting information, particularly the «Explicatio» sections were inconsistent in the depth of the acoustical explanation, simply because of the discrepancy in acoustics literature. The recordings that I made to undertake my own empirical research (to analyse the effect of changing plucking direction on loudness and overtone content and the divergence of cello harmonics from the pitch of the natural harmonic series) would benefit from being considerably expanded, and other similar research projects could be undertaken. One aspect of cello playing that urgently demands such research is multiphonics. Collaboration with acousticians and psychoacousticians could be a valuable way of bringing this research forwards. This will form part of the above-mentioned webpage, with an active «forum» for performers, composers and acousticians to highlight research that would be particularly interesting to pursue, and to comment on the observations of the empirical work as it is undertaken, in short to guide the research according to the need.

More studies and exercises need to be made available to cellists, in order to enable instrumentalists to practice unfamiliar methods, to improve reliability and explore sound possibilities. Instrumentalists rather than composers have traditionally provided this body of work. I would like to call for more such pieces. An exercise exploring *pizzicato* to take up Berlioz' (in my opinion not yet fully satisfied) call for research might be a good starting point, a study to «fine tune» overpressure techniques or to improve the reliability of the pitch content of multiphonics would be further themes worthy of exploration.

Finally, in compiling a literature review in the preparatory stages of *Cello Map*, I was unable to find a complete bibliographical list of the handbooks of modern technique. Such a list urgently needs to be made to enable performers and composers to analyse the literature critically, to identify past successes and mistakes and point to the most strategic path forwards in approaching the problem of modern performance practice. A webpage is the fastest way to circulate information widely. Simply asking participants of the above-proposed forum to provide names and reviews of such handbooks would provide a simple, reader-led, ongoing literature review. To begin this process, the bibliography in the Appendix (p. 97) is a list of all of the handbooks to modern technique that I was able to access as part of my research. I am confident that many more have and will be written.

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- 1 Friedrich Grützmacher, *Hohe Schule des Violincellospiels* (Leipzig, 1891).
 - 2 David Popper, *Hohe Schule des Violincellospiels*, Op. 72, 2 Vols. (Leipzig, 1901-5).
 - 3 Louis Feuillard, *Exercices Journaliers pour Violoncelle* (Paris: Schott, 1919).
 - 4 R. Caroline Bosanquet, *The Secret Life of Cello Strings. Harmonics for Cellists* (Cambridge: SJ Music 1996).
 - 5 Siegfried Palm (ed.), *Pro musica nova. Studien zum Spielen neuer Musik: für Violoncello* (Wiesbaden: Breitkopf und Härtel 1985).
 - 6 Garth Knox, *Viola Spaces: Contemporary Viola Studies* (Mainz: Schott 2009).
 - 7 Tarr and Dickey, *Articulation in Early Wind Music*, p. 84.
 - 8 Hector Berlioz, Richard Strauss, *Treatise on Instrumentation*, trans. Theodore Front, New York: Dover 1991, p. 35-36.
 - 9 Weiss and Netti, *The Techniques of Saxophone Playing*, Chapter 3b.
 - 10 Dick, *The Other Flute*, 46.
 - 11 Schneider, *The Contemporary Guitar*, 135.
 - 12 Van Cleve, *Oboe Unbound*, 75.
 - 13 Gardner Read, *Compendium of Modern Techniques*, Westport: Greenwood Press 1993, p. 92-100.
 - 14 Strange, *The Contemporary Violin*, p. 41.
 - 15 *Cello Map* is a handbook for cello technique Ellen Fallowfield recently completed under the supervision of Erik Oña at the Hochschule für Musik Basel and the University of Birmingham, UK as a PhD-Project.
 - 16 Garth Knox, *Viola Spaces. Contemporary Viola Studies*, Supplementary booklet (Mainz: Schott 2009).
 - 17 Harmonics are presented separately to «excitation of the string». Many of the acoustic principles regarding harmonics require further explanation, and are sometimes considerably different to *ordinario* stopped string vibration. Were the two to be presented alongside one another the text would be very fragmented.

→ 95 
